# User Manual for the
# Sandwich Box Mk3
## Independent Vibrator Quality Control Test System

## Software Version 3.03


**Verif-i Limited**
**Chiltern House**
**Marsack Street**
**Reading**
**RG4 5AP**
**United Kingdom**
**Tel** +44 118 972 2236
**Fax** +44 118 947 9743
**Email** info@verif-i.com
**Web** www.verif-i.com

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Revisions:

| Rev. | Date | Page(s) | Change |
|---|---|---|---|
| | | | |

# Table of Contents

## Safety First

The Sandwich Box uses independent accelerometers to monitor the performance of a vibrator while it is sweeping. Normal operating procedures should be adhered to when working on a vibrator to prevent injury or damage to equipment. Correct personal protective equipment should always be worn when working on or around vibrators and the vibrator should never be pressured up when mounting, dismounting or moving the accelerometers.

Note that the AC power supply included with the Sandwich Box is for indoor use and is not suitable for use in damp or wet conditions.

The Sandwich Box uses long cables and should not be used during electrical storms or near high voltage power lines.

# Introduction

The Sandwich Box is a signal acquisition and processing system for recording and analysis of vibrator sweeps using independent accelerometers.

The system consists of software, running on Windows operating systems, and hardware consisting of an eight channel acquisition unit along with accelerometers and cables. Any or all of the Sandwich Box inputs may be configured to record data from accelerometers powered by current sources built into the Sandwich Box.

Signals are displayed in real time during acquisition and can then be saved to disk and processed when acquisition of a sweep is complete.

All input signals are buffered in the Sandwich Box and outputs are provided for connection to a seismic acquisition system. In addition a vibrator weighted-sum ground force signal created from accelerometer signals on channels 1 and 2 is computed inside the Sandwich Box and output on one of the front panel connectors. This signal can be connected to the recording system and used to determine vibrator polarity.

# Changes from Sandwich Box Mk2

The Sandwich Box Mk3 hardware has been completely redesigned to use the latest generation of seismic A/D converters but the software has been kept similar to the Mk2 version. The Mk3 drivers will load under Windows 8.

The following lists some of the differences between the Mk2 and Mk3 Sandwich Box hardware:

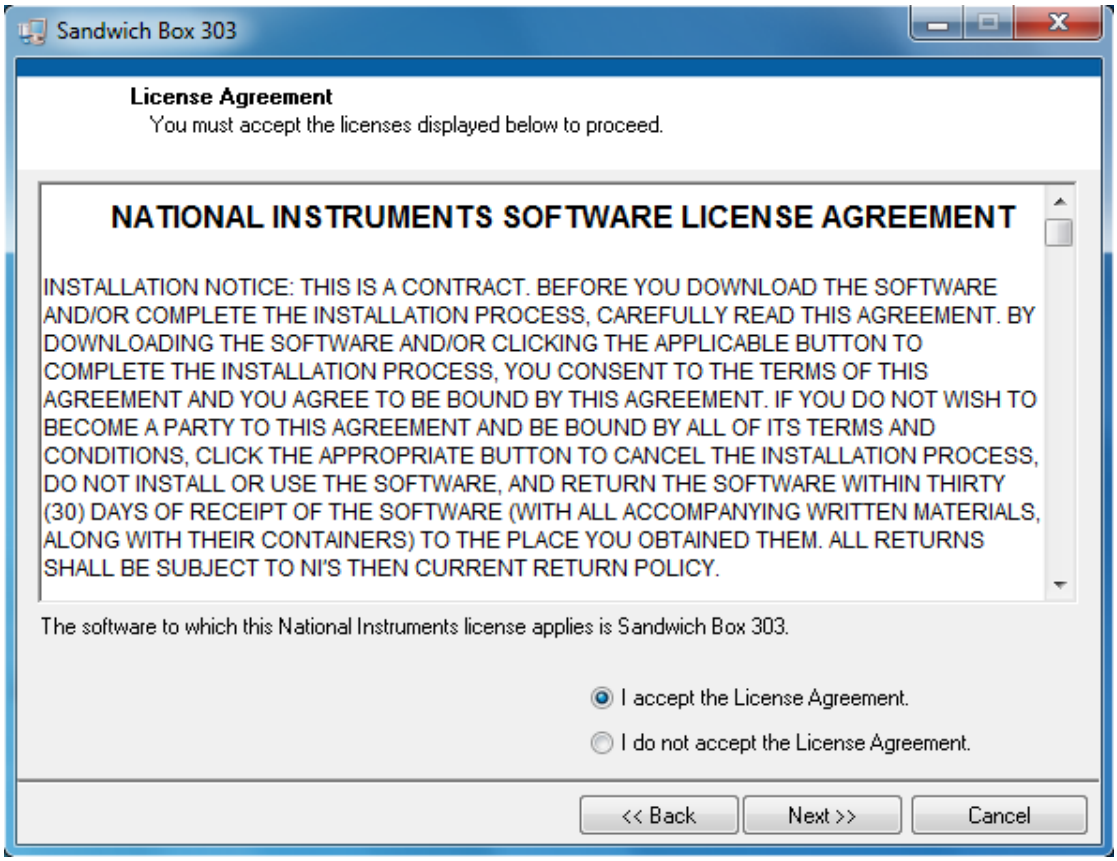
- The software is not compatible between the two versions and the correct version of software should be used - if a Mk3 Sandwich Box is used with Mk2 software an error message will be displayed
- The Sandwich Box Mk3 supports differential inputs, e.g. the signals on the Similarity connector of Sercel DSDs
- The voltages on the Output front panel connectors are differential. The user should avoid grounding either the positive or negative output pins, e.g. when connecting to an oscilloscope input
- The polarities of all outputs are now the same as the inputs
- The unit can record data synchronously when triggered by a hardware signal
- The maximum input voltage has been increased to ±15 V so reference signals from Pelton vibrator electronics do not require attenuation

## Software Installation

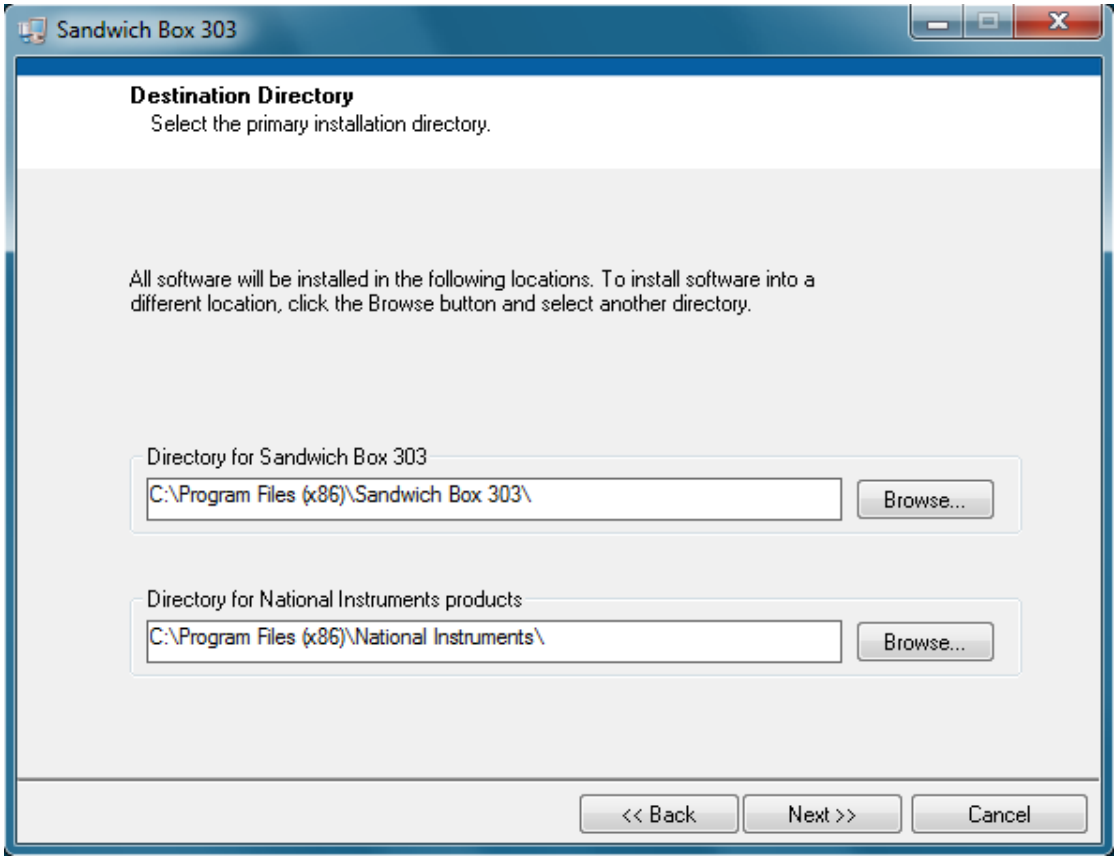
The software runs on Vista, Windows 7 and Windows 8. Drivers are provided for both 32 and 64 bit versions. Note that Administrator rights are required to install the programme and drivers.

The software is contained on a CD supplied with the Sandwich Box or can be downloaded free by users of Sandwich Box hardware from Verif-i's website www.verif-i.com/upgrades. The software is installed by running Setup.exe from the Sandwich Box USB folder on the distribution CD or from the unzipped file downloaded from the website.

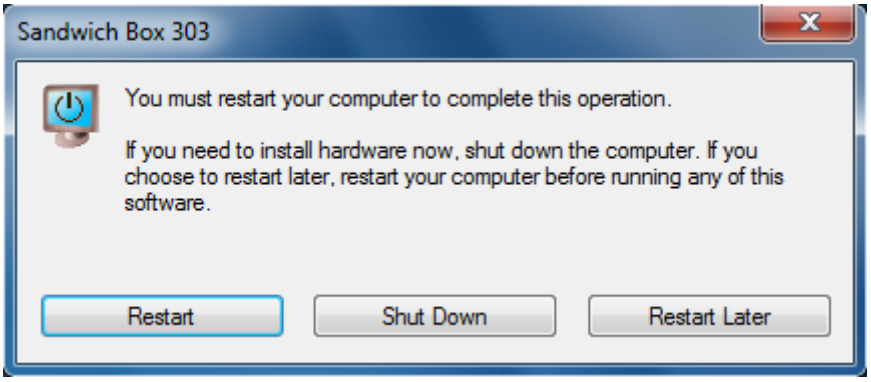
The first thing that the software installation does is to load the National Instruments runtime engine which is required to run the Sandwich Box software. The user must accept the terms of the licence agreement to continue.




By default the Sandwich Box software is installed in folder called Sandwich Box 303 in the Program Files folder or Program Files (x86) folder on 64 bit operating systems. The location of the software may be changed by the user during software installation however it must be loaded on the same partition as the Windows operating system.



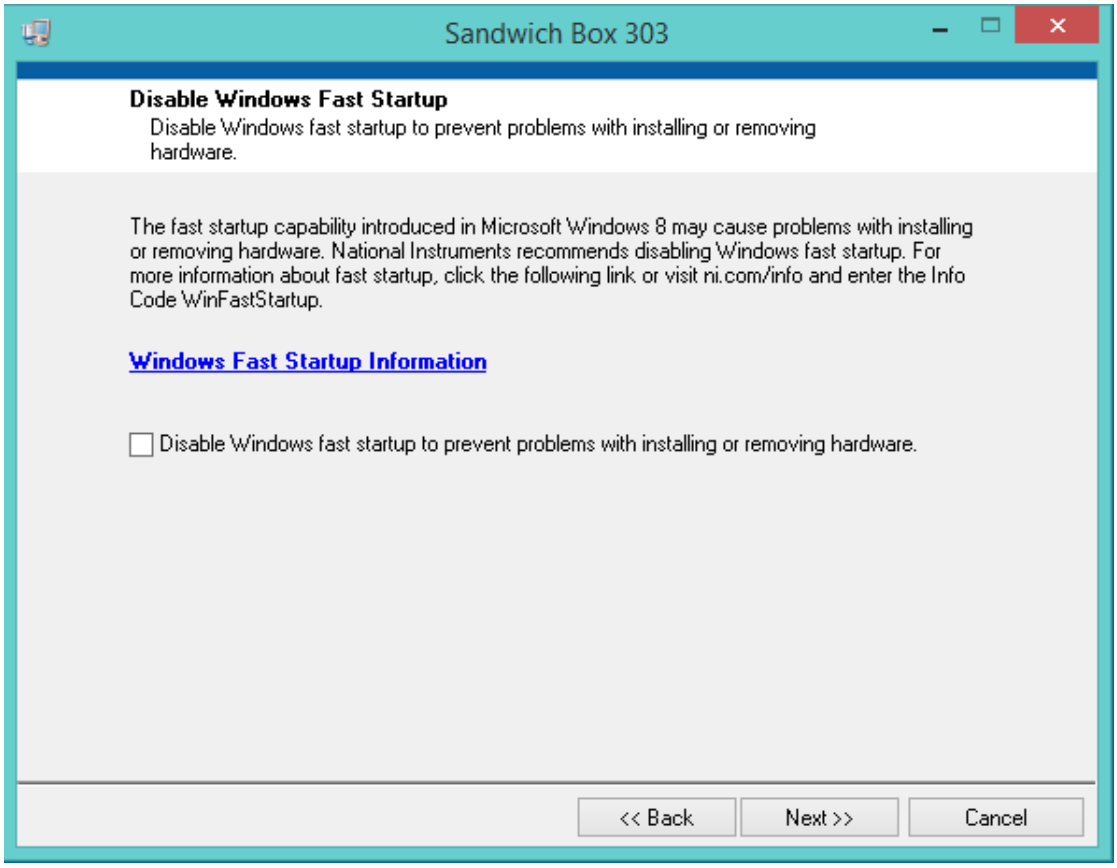

After the runtime engine and Sandwich Box software have been installed the PC must be restarted.




When the computer has been restarted the software may be used to process data acquired on a different PC. If the PC is to be used to acquire data using a Sandwich Box then the USB driver must be installed.

## Note for Windows 8 users

When installing the Sandwich Box software on a Windows 8 PC an extra window is displayed with the following warning.

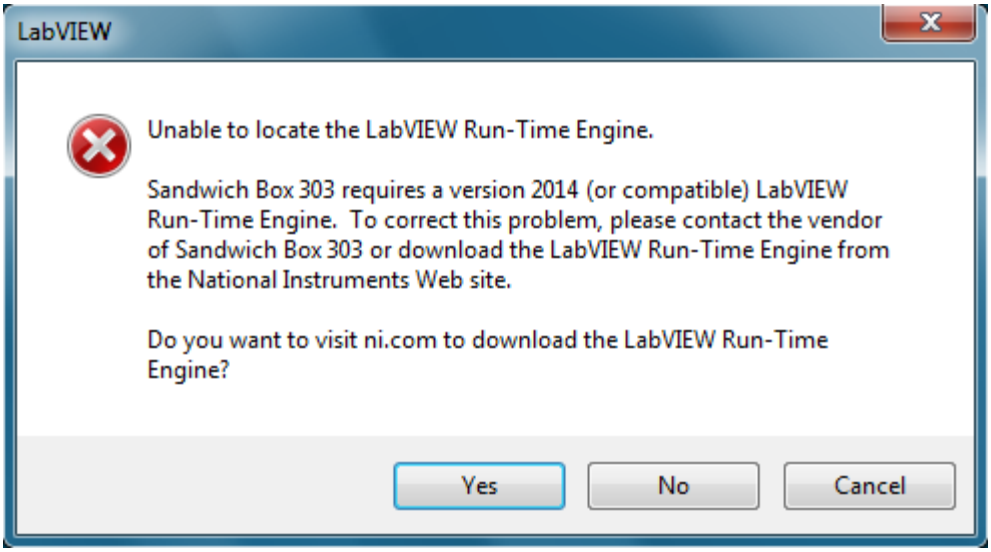



It is not necessary to disable Fast Startup for the Sandwich Box so the box should be unticked, as shown above, and installation continued.

## Upgrade Software

A special Upgrade version of the Sandwich Box software may be available. The upgrade version is identical to the Full release except that it does not include the runtime engine, making the installation files much smaller. This can be loaded onto PCs that already have the runtime engine installed, e.g. when upgrading the software.

Installation for the upgrade version is similar to the full version except there is no National Instruments licence agreement. If the Sandwich Box software is launched and a suitable runtime engine is not available the following error message is displayed:



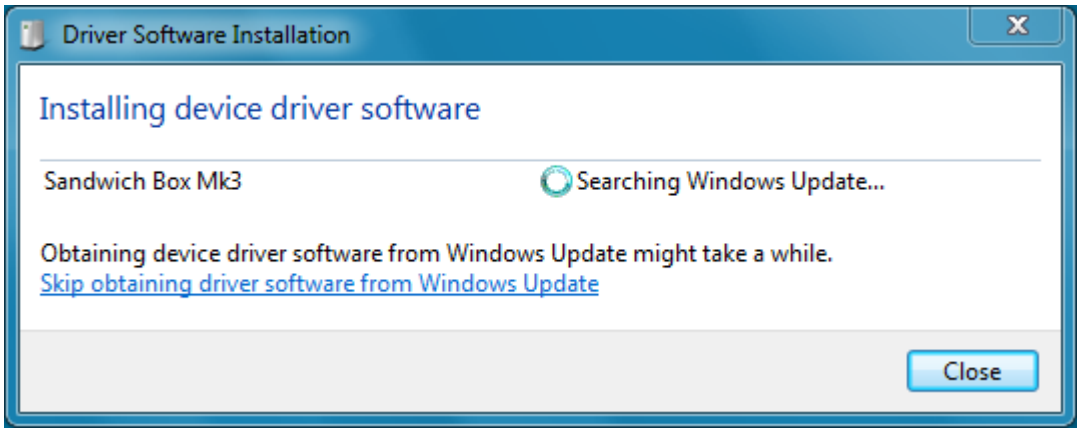

If this message is seen the full version of software should be installed.

## Driver Installation

The Sandwich Box Mk3 attaches to a USB port of the host computer (either USB 2 or 3) and a software driver is required to enable communication between the PC and the Sandwich Box. The software may be loaded on a computer without a driver to allow data recorded with a different PC to be processed.

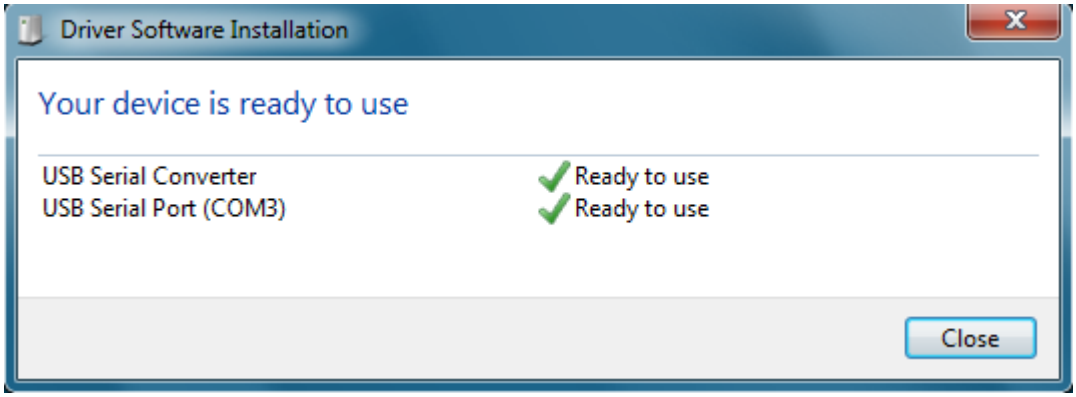
Driver must be installed before the unit can be used for data acquisition. The driver supplied with the Mk3 Sandwich Box is a generic USB driver that is Microsoft Certified which means that it is available on the Windows Update site and installs without warnings.

Connecting a Sandwich Box to a PC with a USB cable for the first time and powering up the Sandwich Box causes Windows to search for a driver in the operating system and then, assuming there is an internet connection, on the Windows Update site:

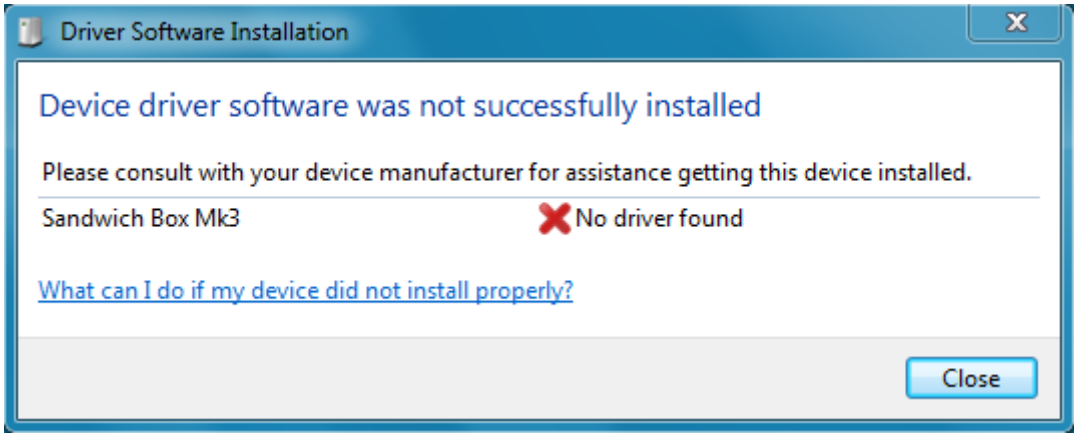



If

If the driver is found then it will be automatically downloaded and installed by the operating system.

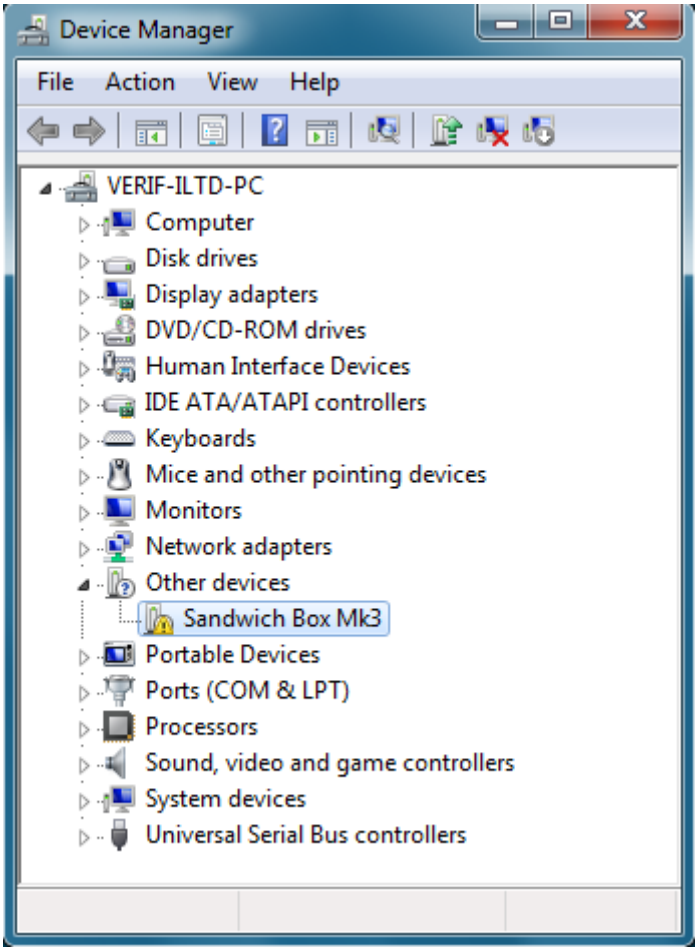



If for any reason a driver is not found on the Windows Update site, for example the PC is not connected to the internet, then the following warning will be displayed:

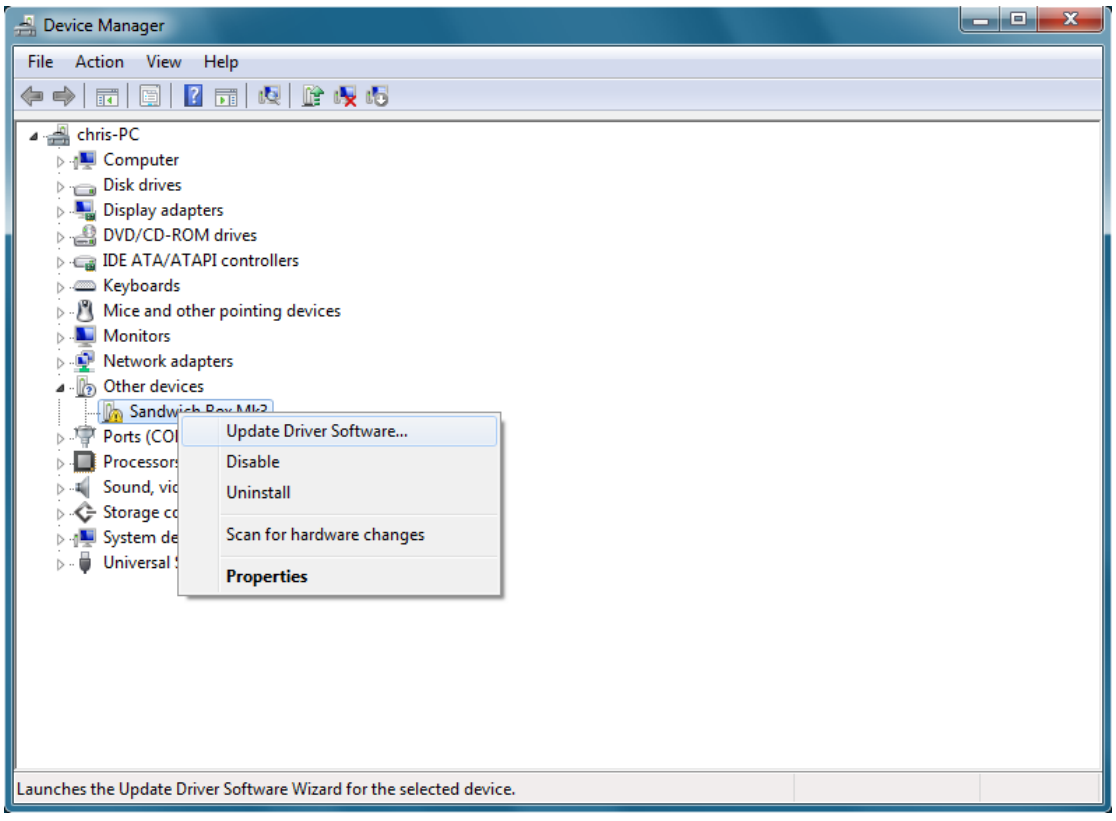



In this case the driver has to be installed manually.

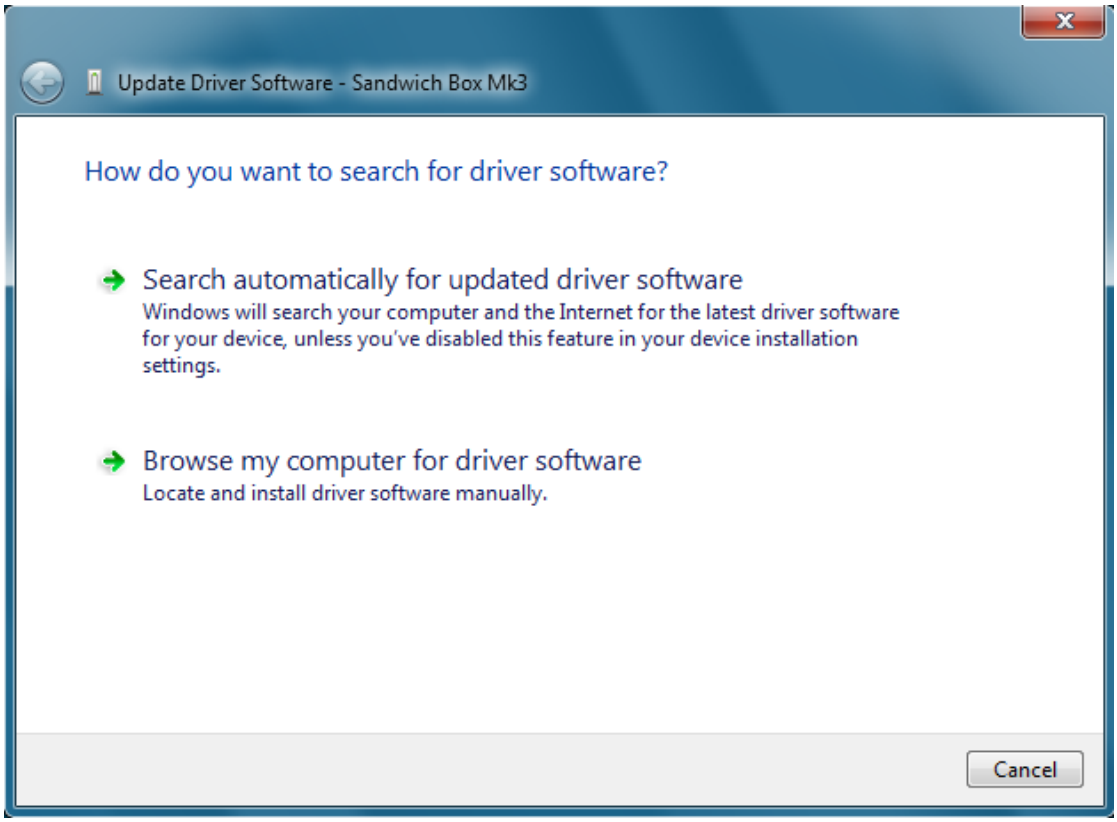
To load the driver manually, click on Start then Control Panel and Device Manager. This will list the hardware connected to the system, including the Sandwich Box which will appear under the Other devices category, as shown below:




Right-click on Sandwich Box Mk3 and select "Update Driver Software..." from the menu that appears.

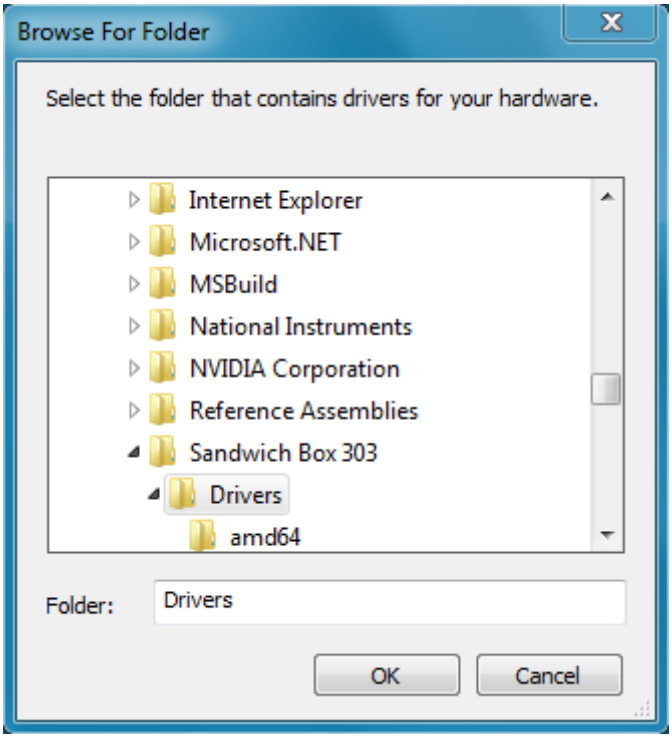


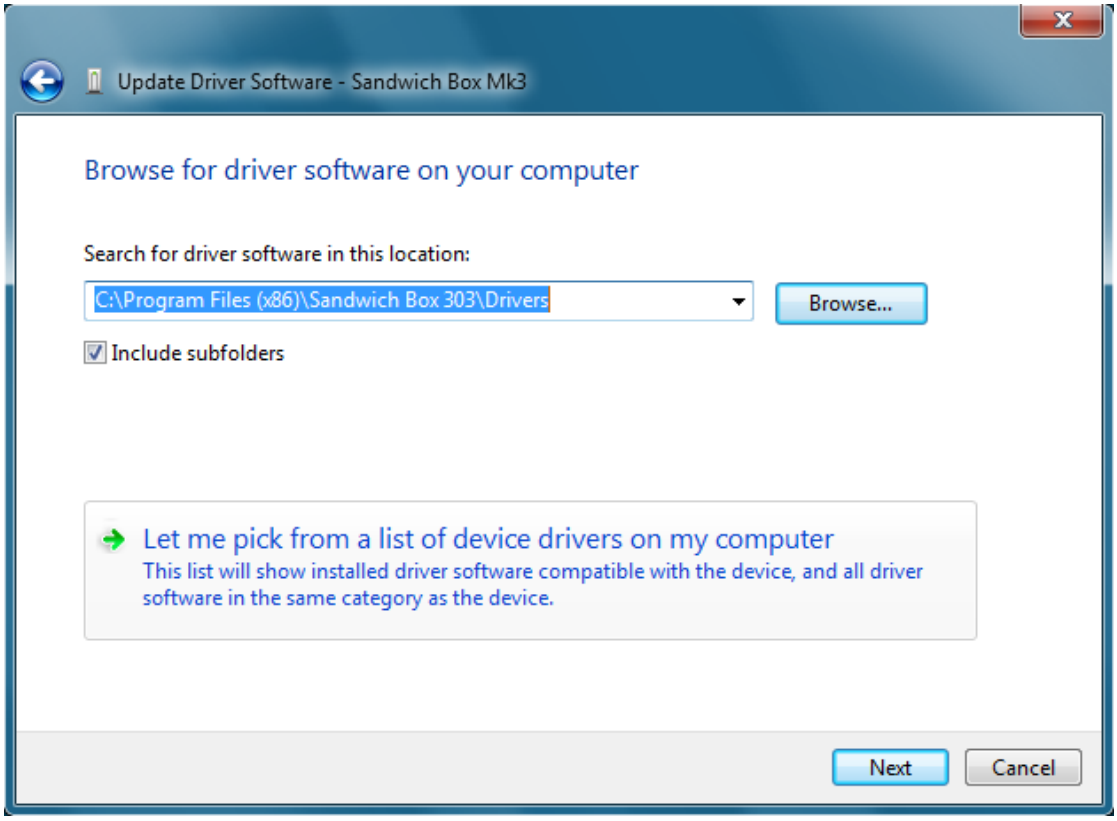
This brings up the following window:



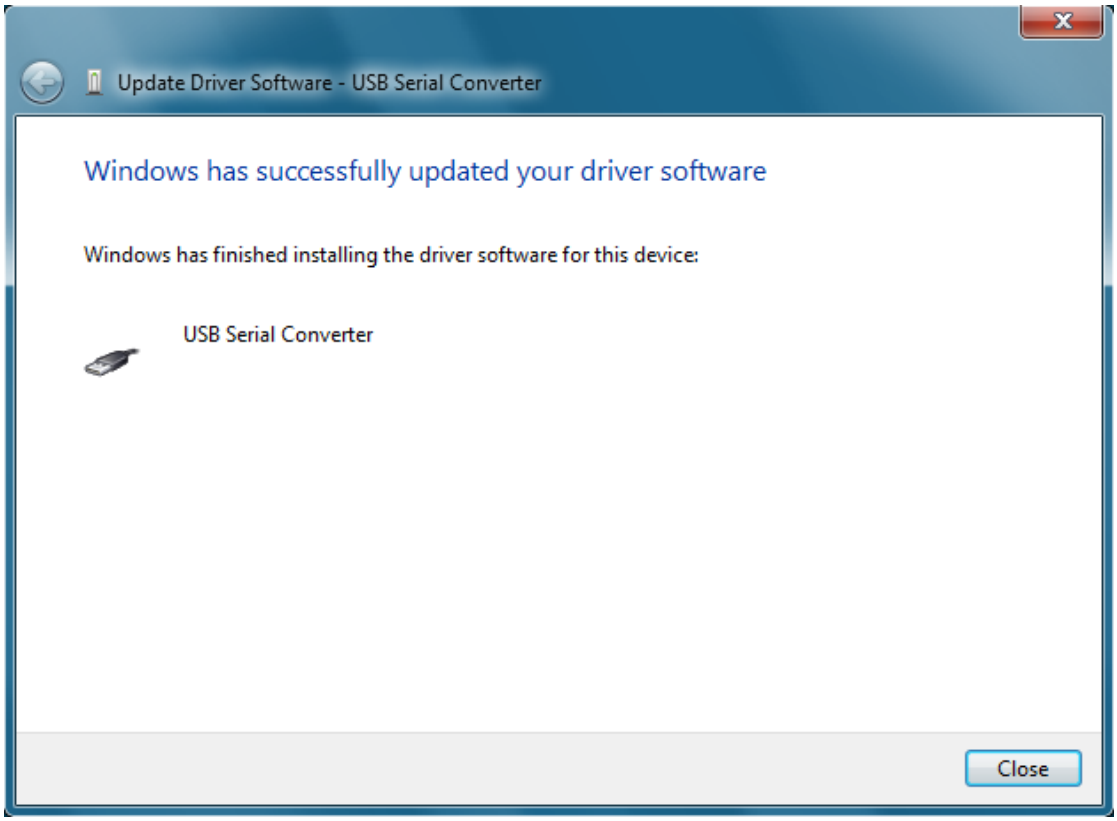

Select the second option, "Browse my computer for driver software" and navigate the Sandwich Box software, whose default location is:

C:\Program Files\Sandwich Box 303\Drivers



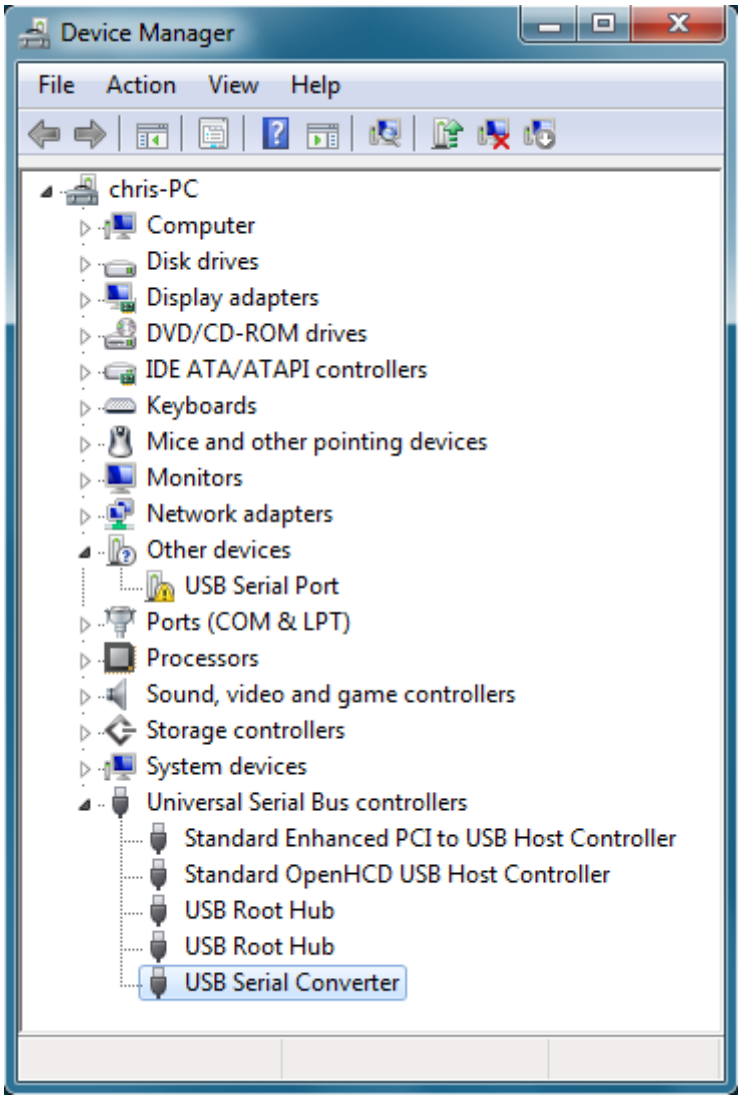



Selecting Next will load the driver and on completion a Window will be displayed indicating that the driver has been loaded successfully.



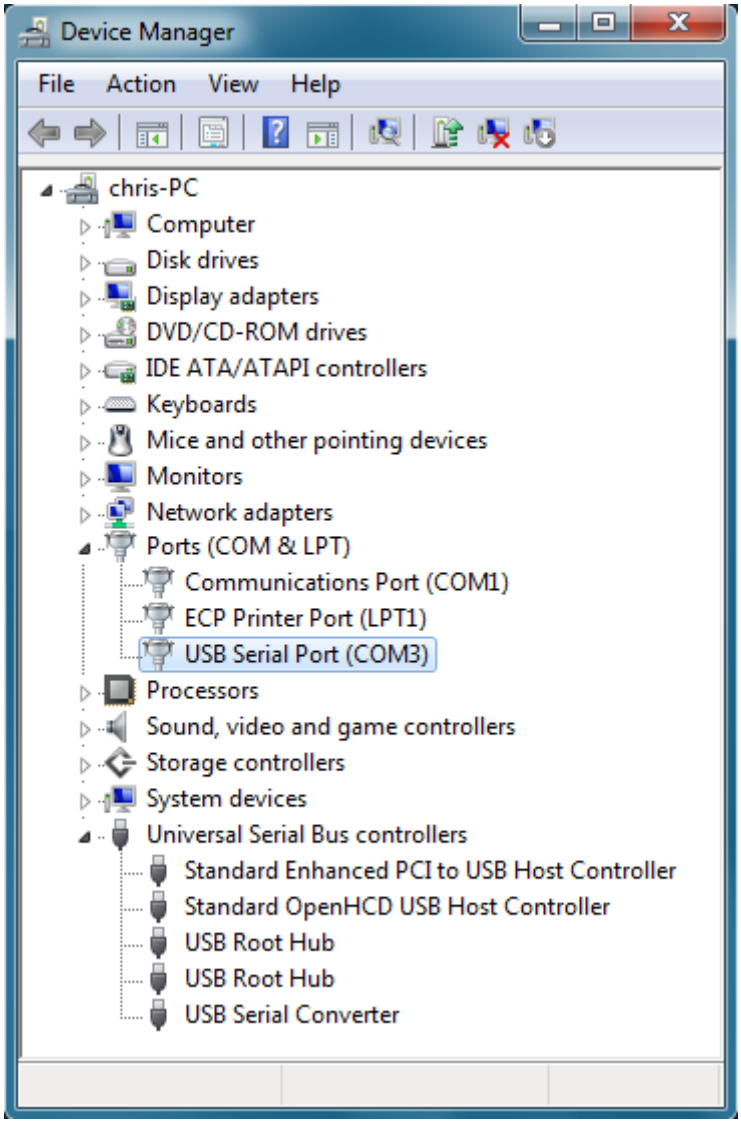

Note that the Sandwich Box is identified as a generic USB Serial Convertor rather than specifically as a Sandwich Box. Click Close to end the driver installation programme. The Sandwich Box can now be used for acquisition.

Checking the Device Manager should now show that the Sandwich Box is recognised as a USB device.




Note that after the USB Serial Convertor driver is loaded a USB Serial Port device appears in the device manager. This is part of the Sandwich Box hardware interface that is not used and can be ignored however the warning can be removed by repeating the driver installation process above, starting by right clicking the entry in the device manager.

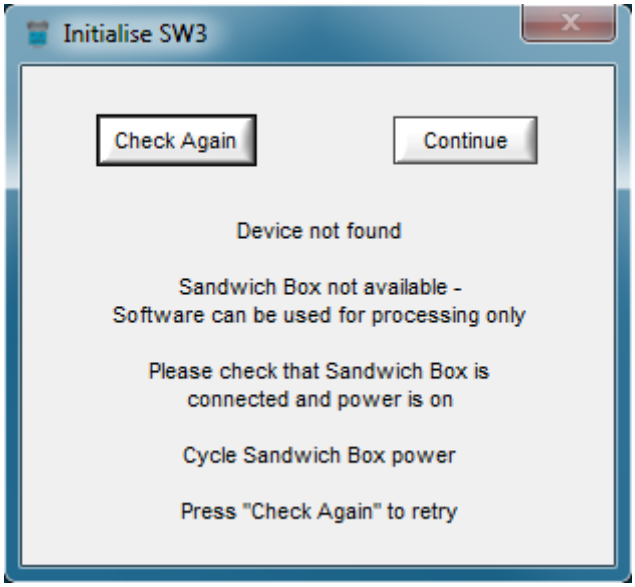
When the USB Serial Port driver has been installed a USB Serial Port appears in the device manager, as shown below:



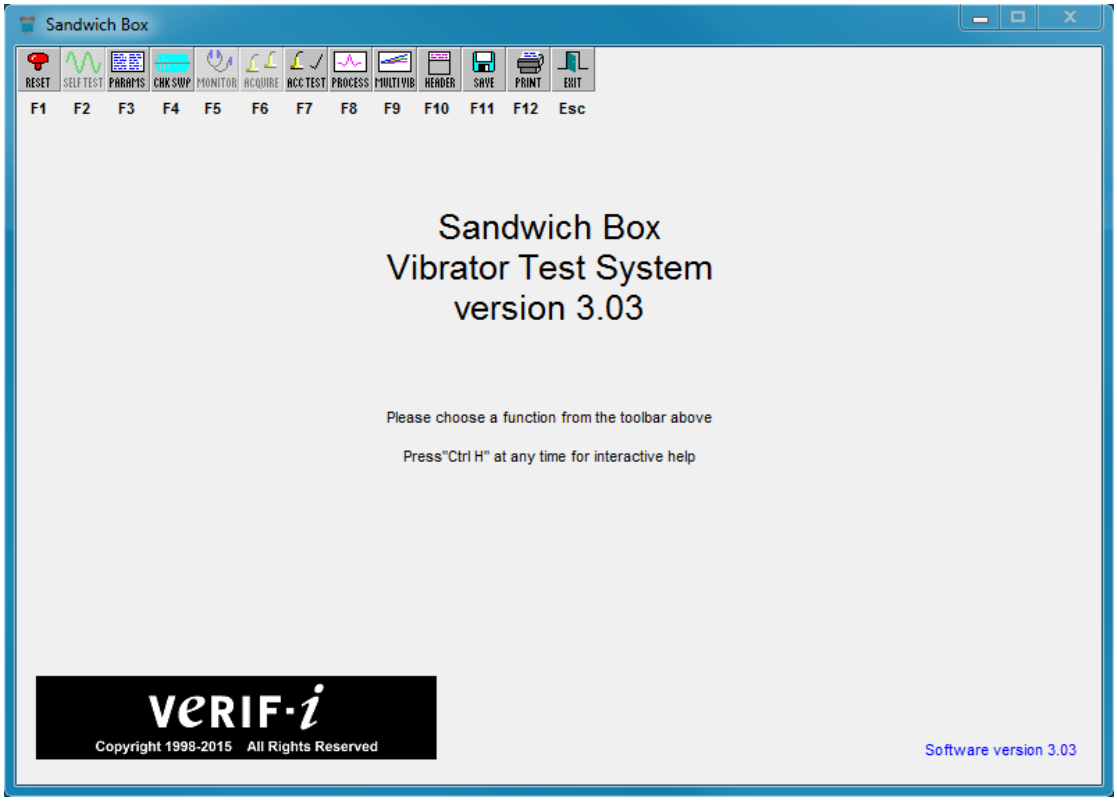

When the Serial Converter driver is listed in the device manager the Sandwich Box hardware is ready for use.

## Use Without Drivers

If a PC is to be used to process files previously recorded Sandwich Box files the driver does not need to be loaded. When the Sandwich Box software is launched and no driver is detected (or no Sandwich Box is connected to the PC) a warning message is displayed:




Clicking the Continue button allows the software to be used to process Sandwich Box data but the acquisition modules cannot be used. The icons for the acquisition icons will be greyed out:

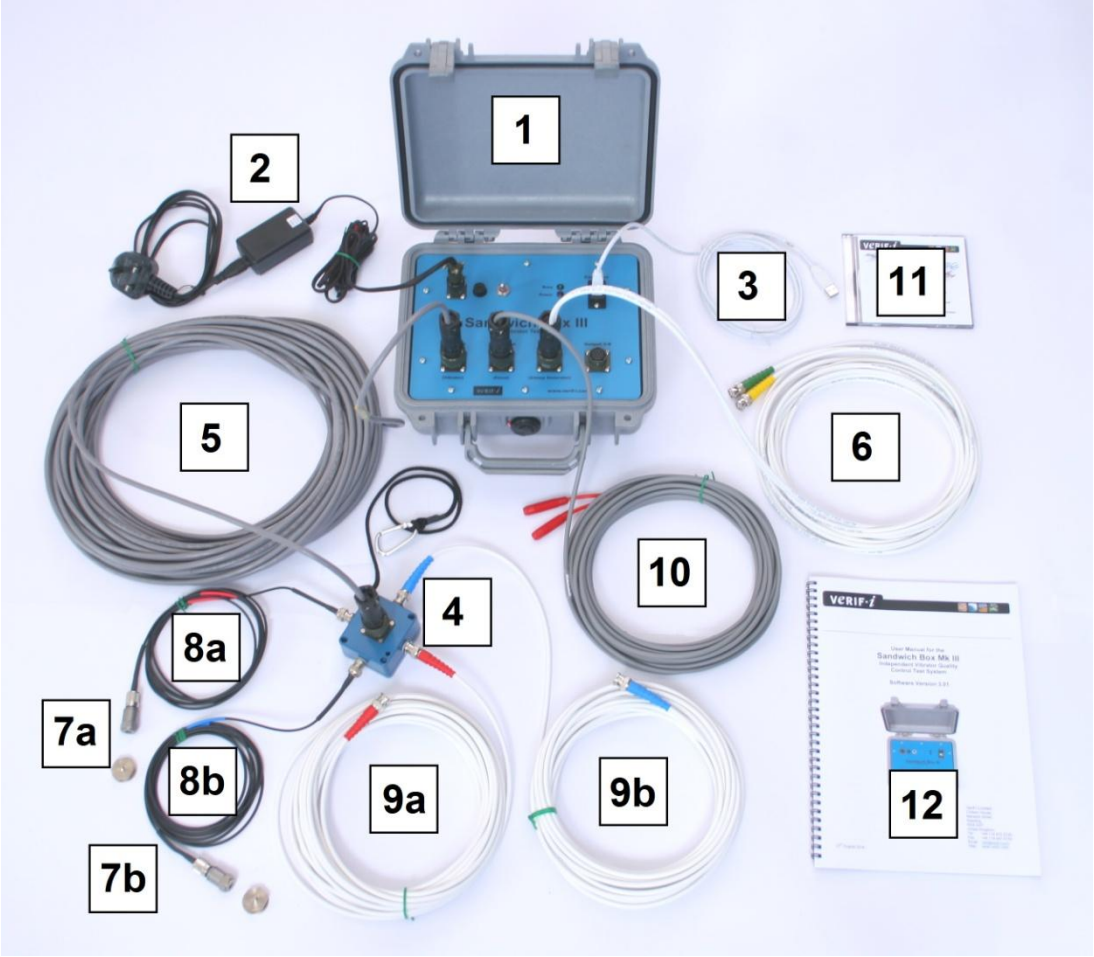



The processing and display modules can be used as normal.

# Deliverables

The Sandwich Box is supplied complete with the following parts:

| Item | Qty | Description |
|---|---|---|
| 1 | 1 | Sandwich Box acquisition unit |
| 2 | 1 | 100-240 V power supply c/w mains cable and connector |
| 3 | 1 | USB cable to PC |
| 4 | 1 | 4-channel breakout box with karabiner for attaching to vibrator |
| 5 | 1 | 25 metre cable connecting Sandwich Box to breakout box |
| 6 | 1 | Timebreak/Reference cable to sweep generator |
| 7 | 2 | Accelerometer with magnetic mount |
| 8 | 3 | Accelerometer to breakout box cables (spare not shown) |
| 9 | 2 | Vibrator electronics to breakout box BNC coaxial cable |
| 10 | 1 | Force Output cable |
| 11 | 1 | CD containing software |
| 12 | 1 | Printed user manual |




The picture above shows how the cables are typically connected to the Sandwich Box.

In use the Sandwich Box acquisition unit may be placed in the recording truck with the single multi-way cable (5) run out to the vibrator under test. The cable is connected to a break-out box (4) which can be attached to a

convenient part of the vibrator using the supplied karabiner. Up to four signals from the vibrator can be connected to the break-out box - typically two accelerometers, vibrator reference and timebreak or force output.

Ideally the correlation reference sweep and timebreak from the sweep generator in the recording truck should also be connected to the Sandwich Box, using the supplied cable (6). The green BNC connector should be attached to the Reference sweep which will apppear on channel 5, the yellow BNC connector should be attached to the timebreak which will apppear on channel 7 and is also connected to the digital timebreak circuit. If the sweep generator signal is unavailable then the vibrator may be tested in stand-alone mode using just the reference sweep from the vibrator control electronics - see the Typical Setup section on page 77.

Power may be supplied using the AC/DC adaptor included with the Sandwich Box which accepts mains voltages between 110 and 240 Volts. Alternatively the Sandwich Box can be powered from a 12 volt DC power supply terminated with 4 mm sockets.

## Optional Accessories

The following optional accessories are available:

### Sercel

A cable is available for use with VE432 or VE464 vibrator electronics to connect the Similarity connector on the front panel of the DSD to the Sandwich Box input. This allows the AVS accelerometer signals, DSD reference sweep and timebreak to be recorded on the Sandwich Box.

| Item | Qty | Description |
|---|---|---|
| 1 | 1 | A one metre long cable to connect DSD front panel Similarity connector to the Sandwich Box |

### Pelton

A kit is available to facilitate testing of vibrators fitted with Pelton vibrator electronics. The kit contains the following:

| Item | Qty | Description |
|---|---|---|
| 1 | 2 | Accelerometer mounts to allow independent accelerometers to be mounted in the receptacles on Pelton accelerometers |
| 2 | 2 | Thumbscrews for above |
| 3 | 1 | Three metre long Pelton Vib Pro reference cable |

The Vib Pro reference cable should be used to connect a Vib Pro unit which is configured as a sweep generator to the Sandwich Box. Note that this cable connects the True Reference and Timebreak signals to the Sandwich Box.

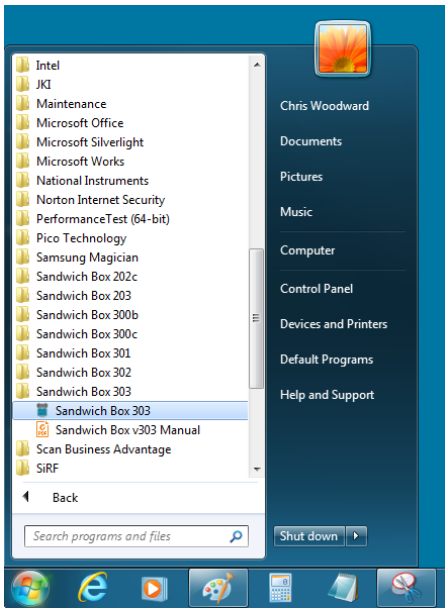
## Force Two

A cable is available to connect the Service cable output of the Force Two vibrator electronics to the Sandwich Box. The signals connected are the Sim Mass and Baseplate accelerometers, Vibrator Reference and Timebreak signals.

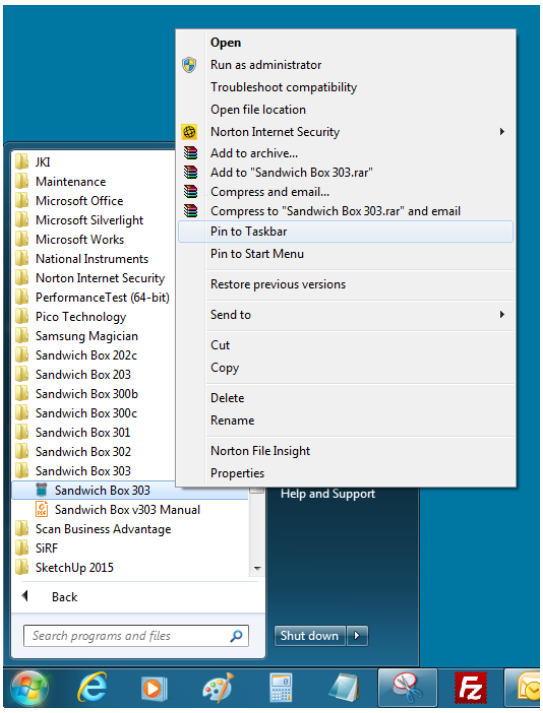
| Item | Qty | Description |
|---|---|---|
| 1 | 1 | A one metre long cable to connect the Force Two DB15 test connector to the Sandwich Box |

# Launching the Software

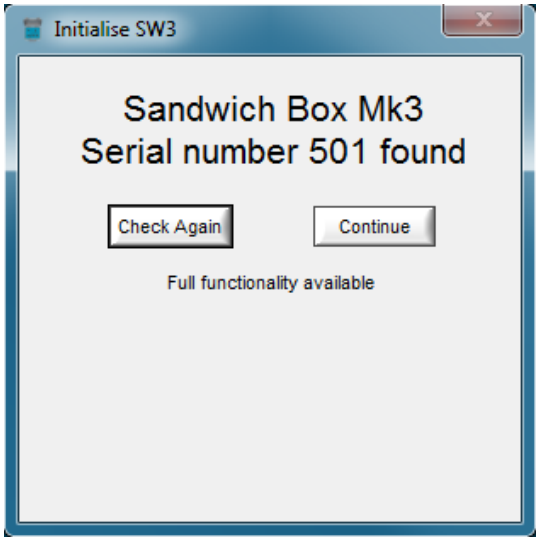
The programme is launched by navigating to Start/All Programs/Sandwich Box 303 and clicking the line Sandwich Box 303.




Note that shortcuts can be made by right-clicking Sandwich Box 303 and selecting one of the highlighted lines from the sub-menus as shown below:

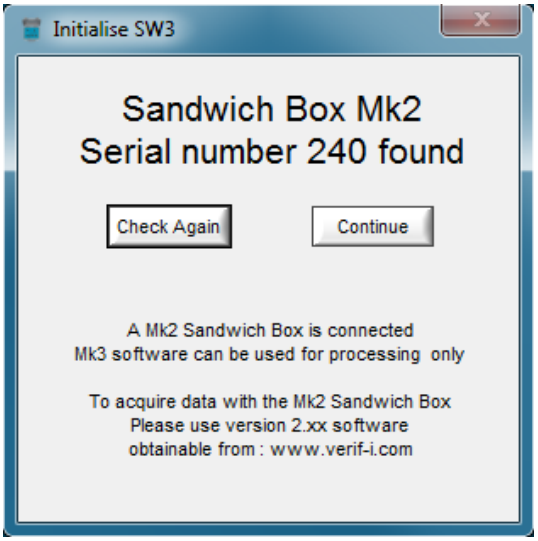



The USB ports are scanned and if a device is found it will be identified by the software.




Clicking Continue establishes connection with the displayed Sandwich Box and enables the hardware to be used for data acquisition. Clicking the Check Again button searches for a different Sandwich Box connected to the PC.

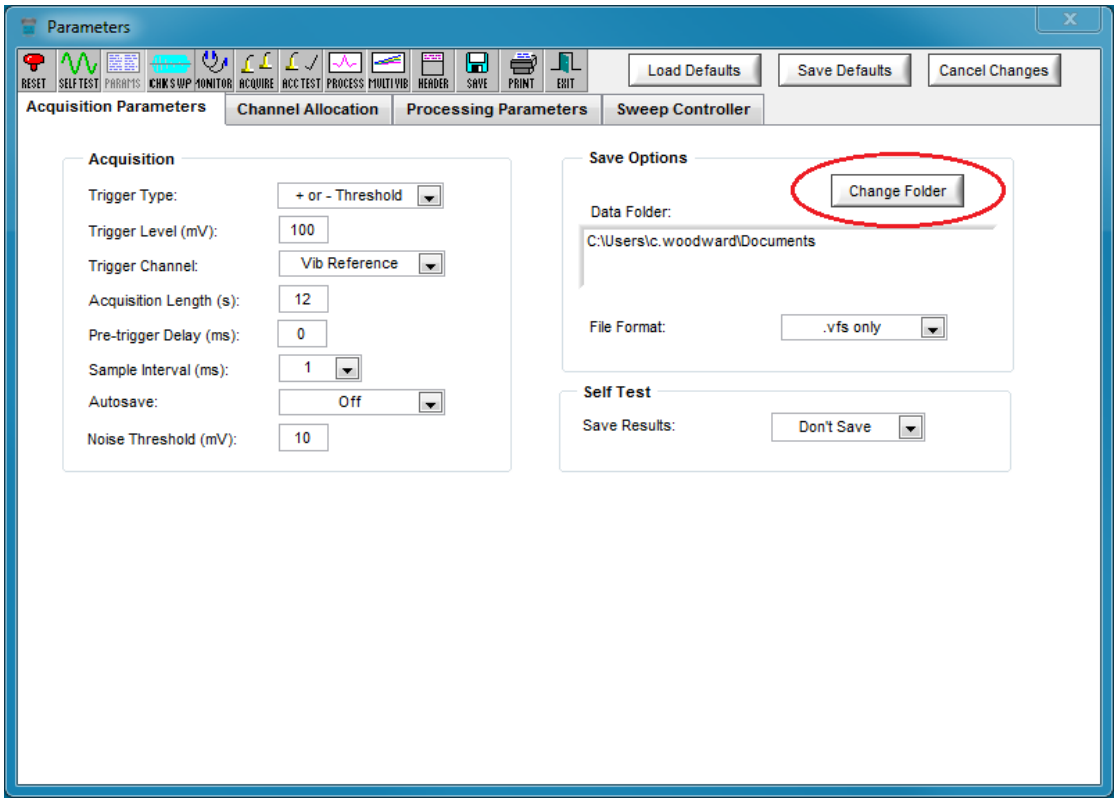
If a Sandwich Box Mk3 acquisition unit is not detected then a warning message is displayed. The software can still be used to process previously acquired data but the Sandwich Box hardware cannot be used. Please see the fault-finding section of the manual for details of how to address this problem.

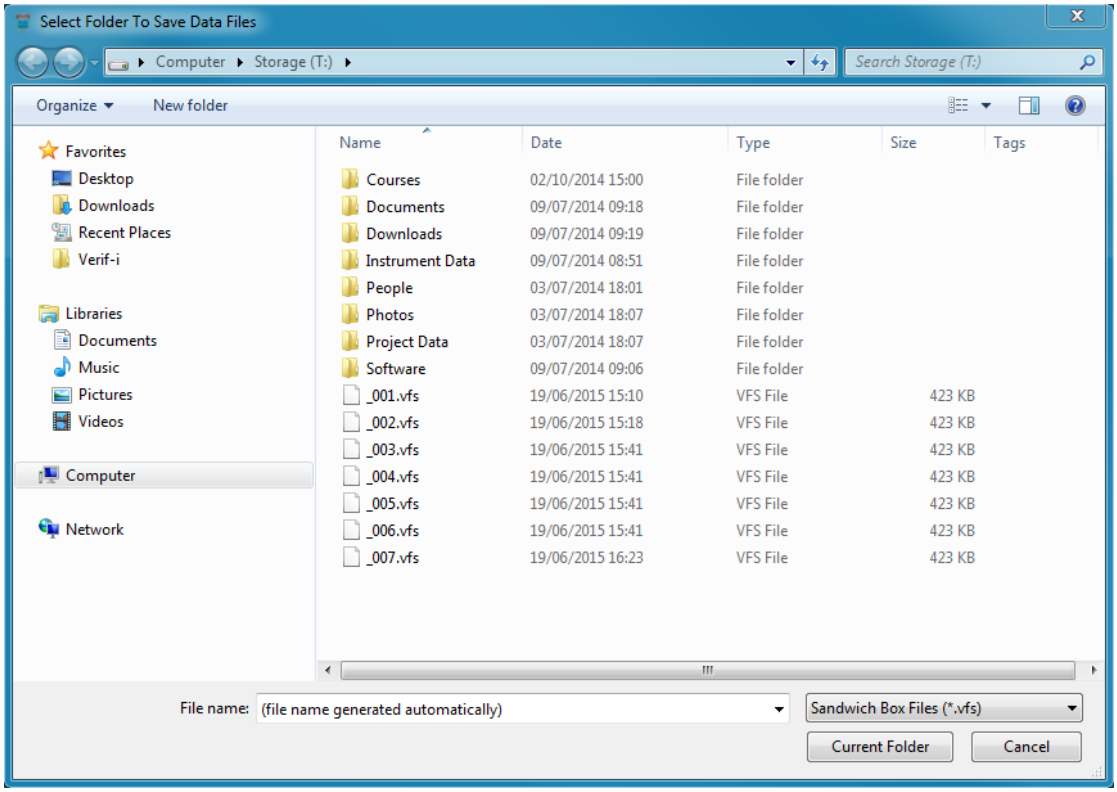

Clicking the Check Again button initiates another scan of the USB ports while clicking the Continue button allows the software to be used process previously acquired data.

# Folder and File Selection

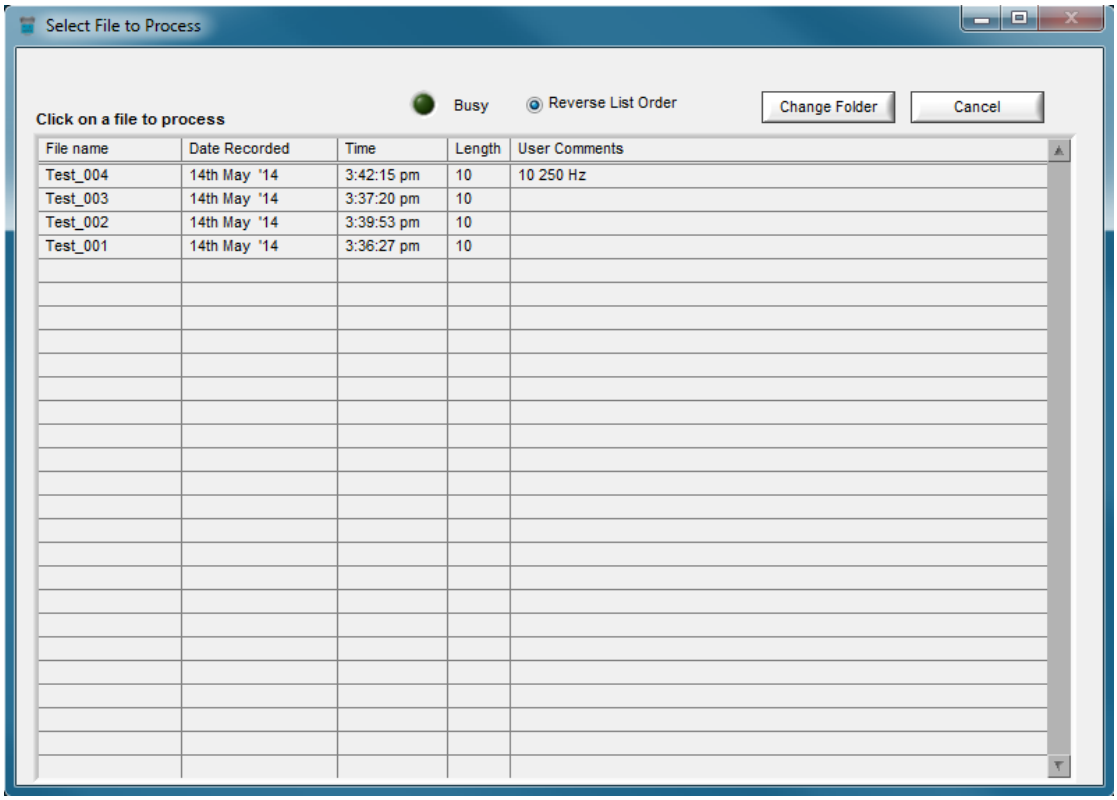
All Sandwich Box data is saved and read from a user selectable folder. The default location of this folder is the user's Documents folder but this can be changed in the acquisition parameters (as shown below) or when manually saving a record.




To change the folder, click the Change Folder button and navigate to the required folder. Click the Current Folder button to select the currently displayed folder. This folder is then used for storing and retrieving all Sandwich Box data files.




When launching the Process, Accelerometer Test or Header Edit modules a table is displayed listing all the Sandwich Box files in the currently selected data folder.



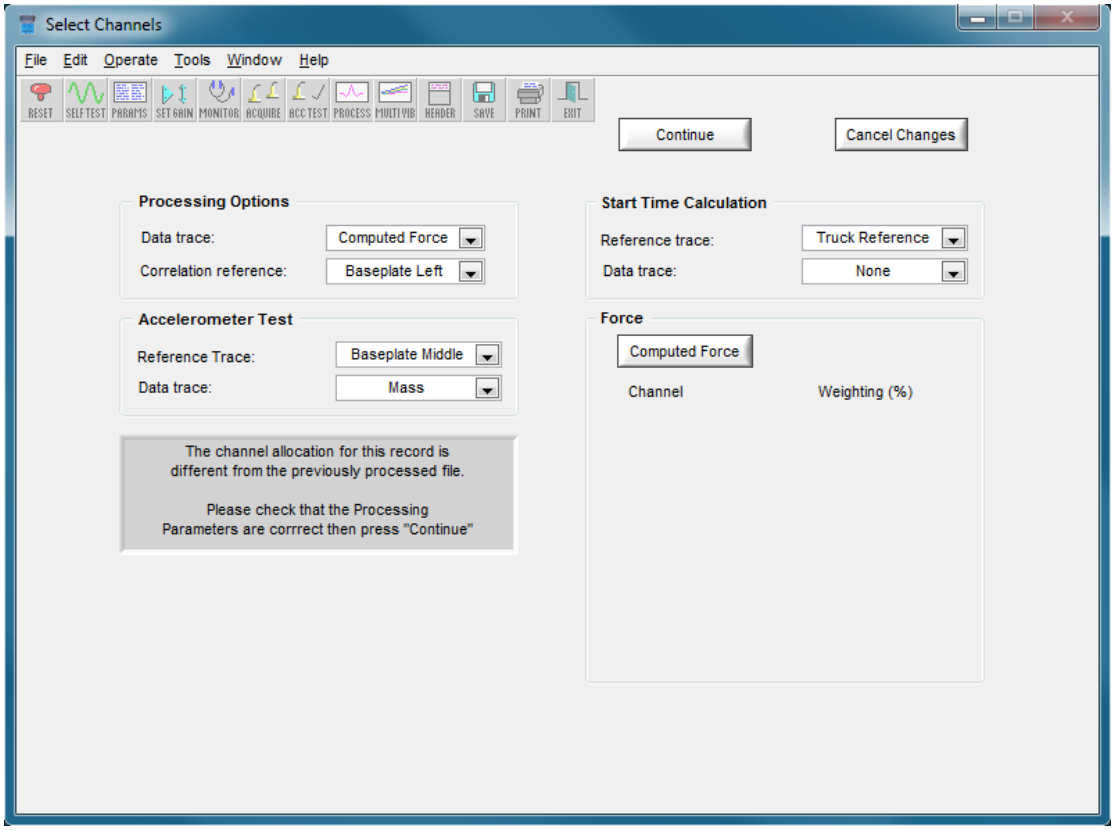

The table shows the filename, some details from the file header and the comments entered by the user at the time the file was saved. The user should select the file to be used by clicking anywhere in the appropriate row in the table.

Note that the Sandwich Box files in the folder are listed in the order that they were recorded, signified by the last three digits of the file name. The first recorded file will appear at the top of the list and the most recent file at the bottom.

The order of the list can be reversed by clicking the Reverse List Order radio button. This causes the most recently acquired file to appear at the top of the list next time the list is read from disk, as shown above. The window can be resized to show more records.

Should the user wish to select files from a different folder pressing the Change Folder button will allow the user to interactively select a different data folder. If a new data folder is selected then subsequently acquired data will be saved in the new folder.

When a record is processed the channel names are read from the record header. If the record contains different channel names from the most recently processed record then the channels selected on the Processing Parameters tab (which are based on the previously processed record) will be different from the new record. In this case the following window is displayed and the user is asked to confirm that the channels selected for processing are correct or change them using the drop-down lists.




Clicking the Continue button will process the data using the currently displayed channel names and clicking the Cancel Changes switch closes the module without changing the parameters or processing any data.

# Icons

The following icons, which are displayed at the top of most Sandwich Box windows, allow the user to launch a new module. The characters in blue type in the list below indicate the Hot Keys (usually function keys) which can be used to execute commands directly using the keyboard.

The blue figures in the list below indicate the hot key and these are hyperlinked to the relevant part of this manual.


**F1** Re-establishes communication with the Sandwich Box hardware.


**F2** Performs a self test using the internal oscillator.


**F3** Opens the parameter editing window.


**F4** Compares a recorded reference sweep with a synthetic sweep.


**F5** Continuous real time display of any one of the 8 input channels.


**F6** Acquires data for saving or processing.


**F7** Processes accelerometer similarity test data.


**F8** Analyses data from a vibrator sweep.


**F9** Processes data from a number of different sweeps for comparison.


**F10** Displays and allows editing of the record header.


**F11** Saves the last acquired sweep to disk.


**F12** Prints the current window to printer or graphics file.


**Esc** Returns to the main menu or exits the programme.

The following icons are displayed for the Results windows only:


**Home** Displays the graphical results on a single page in print format.


**Insert** Closes the Window and returns to the results module.

## Reset

Clicking this icon sends an initialisation code to the Sandwich Box hardware through the USB port.

Use this icon to re-establish communication with the Sandwich Box after connection has been lost (e.g. the USB cable has been disconnected or the power to the Sandwich Box has been cycled).

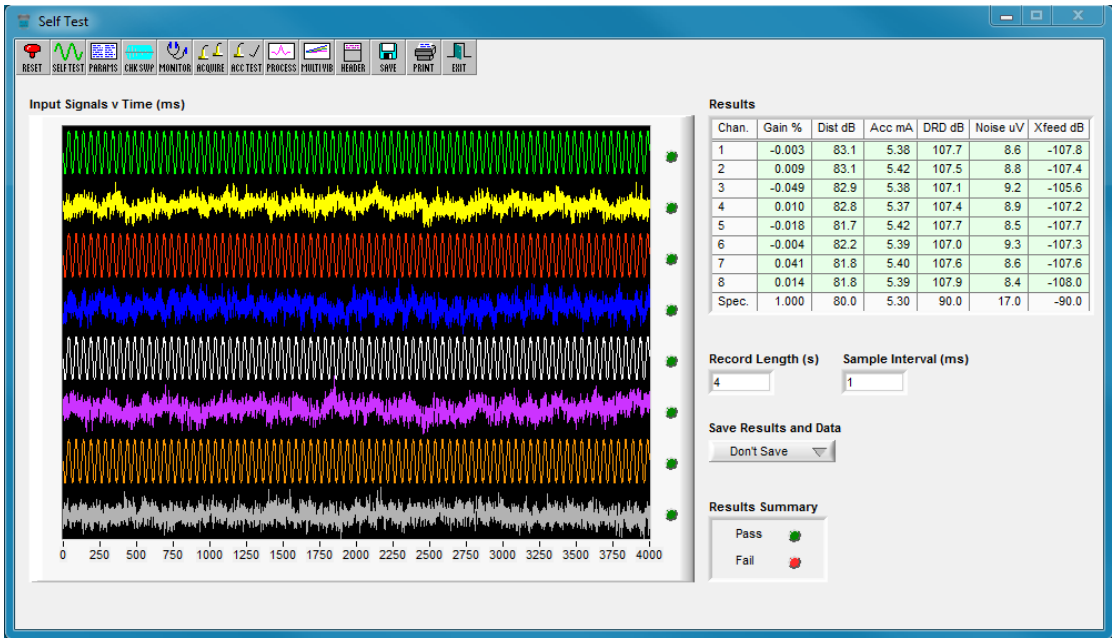
If communication cannot be re-established using this module then power should be cycled on the Sandwich Box hardware.

# Self Test

The self test connects an internal oscillator to the input of all eight recording channels. The signals are wired directly to the front panel connectors so that the entire signal path is tested. All inputs to the Sandwich Box should be disconnected prior to executing the test to prevent external connections affecting the results.

The self test comprises a number of acquisitions that are automatically run in sequence using filter settings and record length selected on the Acquisition Parameters tab. Each test is analysed internally and the results presented in a table; a green background indicates a pass and a red background indicates a failure.

At the end of the series an indicator adjacent to each trace on the plot shows whether the channel passed all of the tests or not.




The test data and/or screen dumps of the individual tests can be saved using the Save Results and Data control on the screen - this control is duplicated on the Acquisition Parameters tab.

A test failure may be caused for a number of reasons; firstly ensure that the front panel input connectors are removed. If a failure persists try cycling power on the hardware and repeating the test. The saved data files can be processed using instrument test analysis software such as Testif-i.

Note that the distortion figure is limited by the quality of the internal test signal generator.

# Parameters

Selecting the Parameters icon allows the operator to view and modify all of the parameters used by the programme. All parameters used by the programme are listed on the four tabs, although some of the parameters can also be accessed in other places.

### Load Defaults

Clicking the Load Defaults button enables the user to retrieve all operating parameters from a previously saved file. By default, parameter files are kept in the user's application data folder.

### Save Defaults

Clicking the Save Defaults button saves all of the current parameters into a file so that they can be retrieved later if required. The parameter files are named by the user and, by default, are saved in the user's application data folder with a vft file extension.

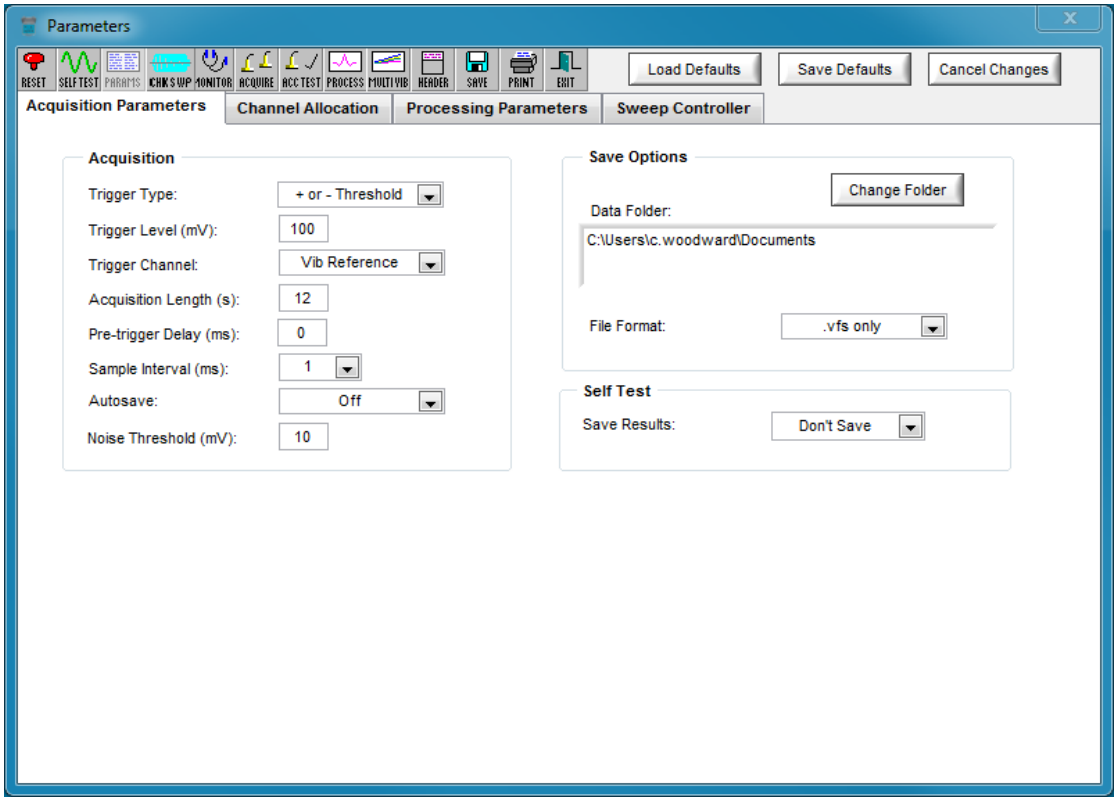
### Cancel Changes

Clicking the Cancel Changes button discards any changes that have been made since the module was launched.

Clicking any of the icons applies the currently selected parameters and launches the selected module.

## Acquisition Parameters

This tab contains parameters describing the recording parameters and data saving options.




The tab is divided into three sections, described below:

## Acquisition

This section contains the acquisition parameters.

### Trigger Type

Recording is started by means of a trigger. The signal on a selected channel is monitored and when the voltage reaches a pre-determined level acquisition is started.

There are two types of trigger, analogue and digital. For the analogue triggers the user selects a threshold voltage and polarity. The hardware monitors the voltage on the selected trigger channel and, when the input signal of exceeds the threshold, acquisition is started on the next sample. As the system is already recording data prior to the trigger the sweep start is asynchronous i.e. subsequent records may not be started at exactly the same point in the sweep, although all channels are sampled at exactly the same time in each record. The user can select whether to trigger on a positive voltage, a negative voltage or either.

The digital trigger requires a positive going logic signal, e.g. a TTL output, as a trigger. When the acquisition module is started the Sandwich Box waits for a trigger voltage to occur and the A/D convertors are only started when the trigger signal is received. This means that subsequent records are sampled at the same time as the initial record however, owing to the delay of the digital anti-alias filters, data is not output for approximately 32 samples after the trigger is received. The output data is padded with data equal to the first valid sample. As the filter delay is not an integer number of samples the residual

timing error is encoded and written in the Sample Skew byte in the trace headers.

**Trigger Level (mV)**

When using a threshold voltage as the acquisition trigger this control sets the amplitude of the threshold in millivolts to initiate an acquisition. If a Digital Signal is used as the trigger then this control is disabled.

**Trigger Channel**

When using a threshold voltage as the acquisition trigger this control selects the channel to monitor. Ideally the trigger channel should be a timebreak signal but if this is not available a reference sweep makes a good alternative.

If a Digital Signal is used as the trigger then this display is disabled.

**Acquisition Length (s)**

The Acquisition Length is the length of time in decimal seconds for which data will be acquired after the trigger threshold is reached. This time will normally be equal to the sweep length.

The maximum record length is 128 seconds, limited by the SEG-D format.

**Pre-trigger Delay (ms)**

The pre trigger delay can be used to acquire data before the trigger threshold is reached. The record length starts at the time the first sample is recorded, which may be before the start of the sweep.

This may be of use when long tapers are being used and a timebreak signal is not available for use as a trigger.

This control is disabled when using a Digital Signal as the trigger.

**Sample Interval (ms)**

This selects the sample interval of the recorded data in milliseconds; the anti-alias filter is automatically applied according to the selected sample rate. Sample intervals of 0.25 ms, 0.5 ms or 1 ms, 2 ms and 4 ms are available.

**Autosave**

The Autosave control can be used to automatically execute one or more modules at the end of each acquisition.

Off - the software waits for user input at the end of each acquisition

Save only - at the end of an acquisition the data is automatically saved using the default values (data folder, comments etc.)

Save then process - the data is saved using default values then processed

Save then acquire - the data is saved then the unit waits for a trigger to start another acquisition

**Noise Threshold (mV)**

During data acquisition the displays on the acquisition plot are normalised to allow signals of significantly different amplitudes to be shown on the same graph. A side effect of this is that noise pickup on channels with no signal applied will be amplified up to full scale. Setting a noise threshold means that signals below this level will not be amplified up by the normalisation process. A suggested value for this control is 10 mV but the amplitude of the noise signals can be viewed in real time using the Monitor module.

### Save Options

This section displays the path of the currently selected data folder where acquired data is saved. Clicking the Change Folder control allows the user to select a different folder to use. Alternatively the first time a file is saved each time the software is used the user is prompted to confirm the folder to use if it has not been changed.

### File Format

The File Format control enables the user to choose to save data in SEG-Y or Testif-i format files in addition to the default Sandwich Box VFS format which is SEG-D. The additional files will be placed in the same data folder as the Sandwich Box format files but will not be listed in the Sandwich Box file display software.

| Data Type | File Extension | Comment |
|---|---|---|
| Sandwich Box | .vfs | SEG-D format |
| Testif-i | .vfi | Verif-i proprietary format |
| SEG-Y | .sgy | |

### Self Test

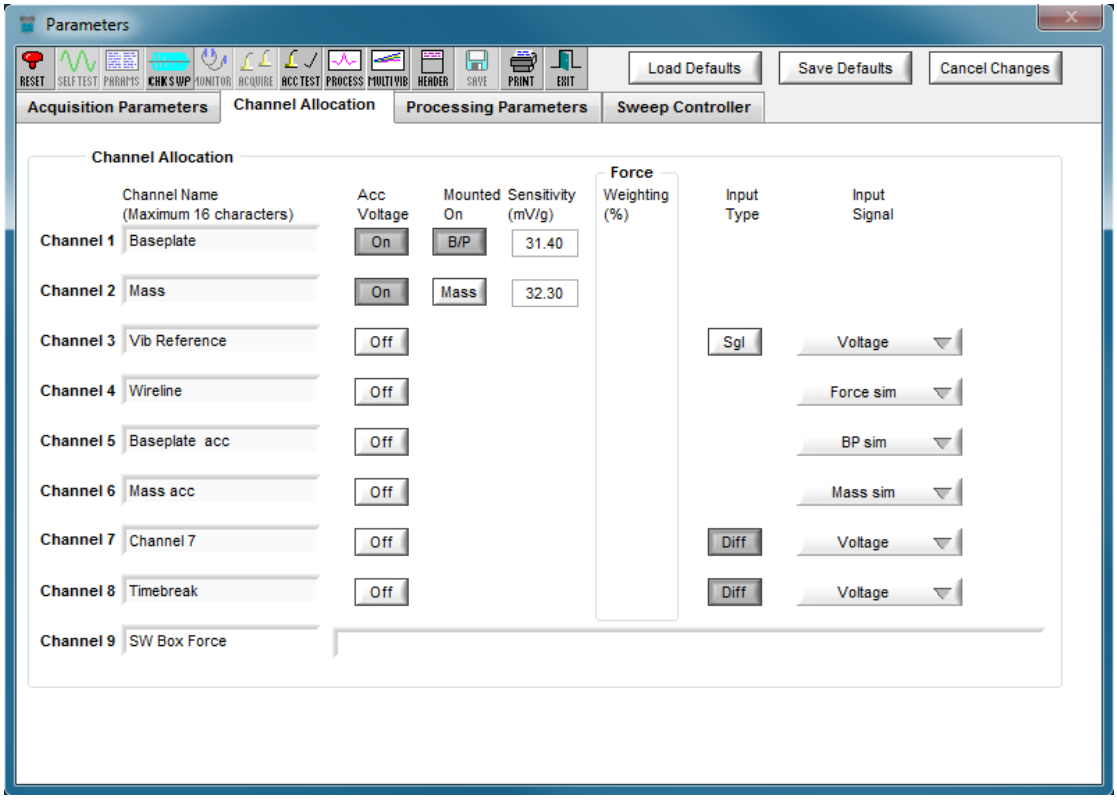
This allows the user to save test data and/or displays from the self tests. Test data is saved in the same folder as the acquired data but the files are given the prefix Selftest, results are saved as graphics files using the format and folder selected in processing parameters.

## Channel Allocation

This tab is used to enter information about the signals connected to the eight input channels. There is one line for each of the eight acquisition channels.

The ninth channel is a calculated force signal provided by software weighting and summing of accelerometer signals recorded on any or all of the eight input channels.

*Note that the force signal available on the front panel of the Sandwich Box is a hardware generated signal which is the weighted sum of the accelerometer signals on channels one and two only.*




The parameters are listed in columns. If an independent accelerometer is attached to a channel then the accelerometer voltage should be switched on and the user should enter the accelerometer sensitivity and indicate whether the accelerometer is mounted on the mass or baseplate. If there is more than one accelerometer on the mass or baseplate then the user also has to enter a weighting value to apply to the accelerometer signal.

If the signal attached to the channel is not an independent accelerometer then the accelerometer voltage should be switched off, in which case the Input Signal and sometimes Input Type controls are displayed.

The options available in the Input Signal list are dependent on the type of vibrator electronics selected on the Sweep Controller tab. The Input Type control selects whether the input to the Sandwich Box is single ended or differential.

In this version of the software the channels cannot be switched off and nine channels are always recorded, eight inputs and the computed force signal.

**Channel Name**

This is a free format field where the user enters the name of the signal connected to the channel. This name is saved with the data for each channel

and is used by the processing modules to identify channels to the user. The channel name can be a maximum of 16 characters (including spaces). Longer names will be truncated and any carriage returns are deleted when exiting the module.

**Accelerometer Voltage**

This switch turns on the five milliamp constant current source used to power an accelerometer. If the accelerometer voltage is switched on then some additional fields are enabled. If the voltage is switched off then different fields are enabled.

**Sensitivity (mV/g)**

The user should enter the sensitivity of the accelerometer attached to the channel. The sensitivity of Sandwich Box accelerometers can be obtained from the accelerometer calibration certificates which are supplied with the accelerometers.

**Mounted On**

The user should select whether the accelerometer is mounted on the Mass or Baseplate of the vibrator under test. This allows the software to apply the appropriate mass weighting to the accelerometer signals to convert them to force.

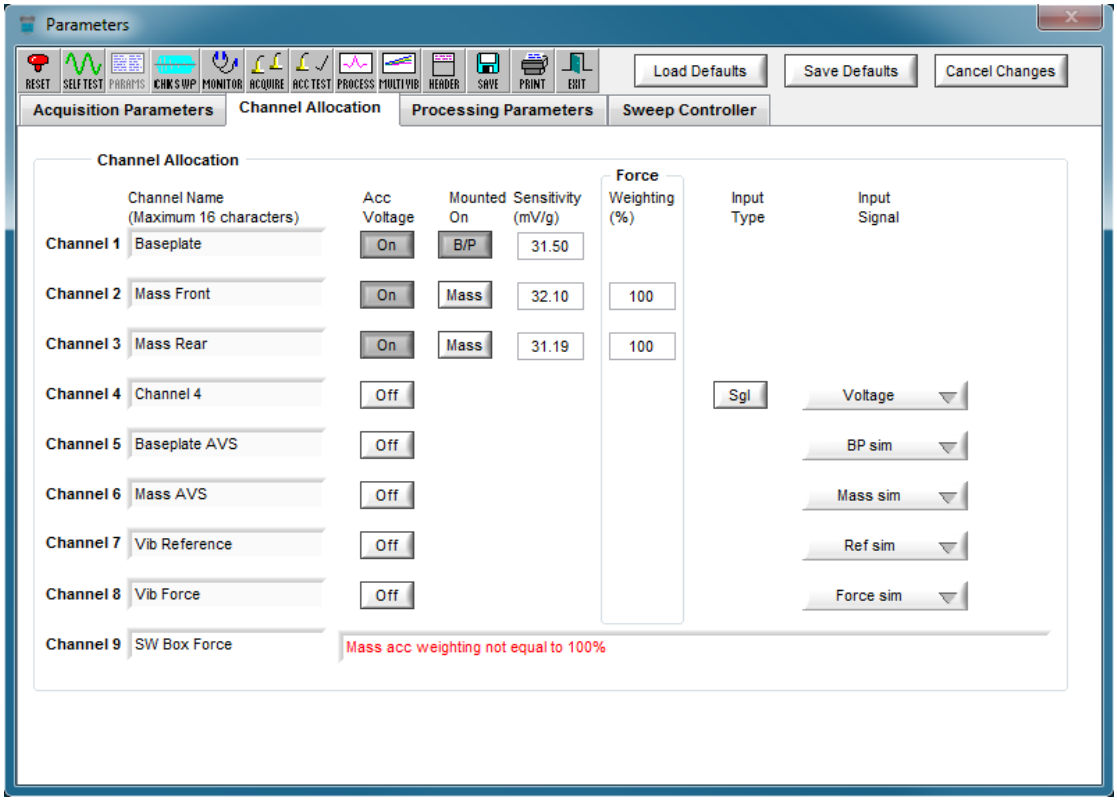
**Force Weighting (%)**

This field allows multiple accelerometers to be placed on each structure of the vibrator to provide a more accurate determination of the ground force signal by averaging the motion of the structure from several readings.

If there is only one mass or baseplate accelerometer then the weighting for this is automatically set to 100 % but if there are more than one of either type then the weighting control is displayed for each accelerometer.

The sum of the weighting of the signals connected to each of the mass and baseplate structures should add up to 100 % so, if there are two accelerometers on the mass they could each be set to 50 %, for example, and if there were three accelerometers on the baseplate these could be set to 30 %, 30 % and 40 %.

If the weightings for each accelerometer type don't add up to 100 % then a warning is displayed as shown below:




The Computed Force signal is always saved as the ninth channel in the saved data and consists of the sum of all the partial force signals, where each partial force signal is calculated by:

$F_{partial}$ = acceleration x structure mass x weighting

$F_{ground} = \sum F_{partial}$ summed across all accelerometers used

Note though that the force output on the front panel of the Sandwich Box only consist of the weighted sums of the accelerometers on channels 1 and 2. This signal is intended to be used for vibrator polarity verification.

**Input Type**

The Sandwich Box Mk3 can be configured for single ended or differential input signals. Single ended signals have one active signal whose voltage is referenced to ground while differential inputs have two active signals which have similar amplitude but are of opposite polarity.

Most sweep generators have single ended outputs however care should be taken as connecting a differential signal to a single ended input will short one of the active signals to ground which will halve the effective input voltage and may damage the equipment supplying the signal. Consult the user manuals of equipment to be connected to find out which type of signal to use.

**Input Signal**

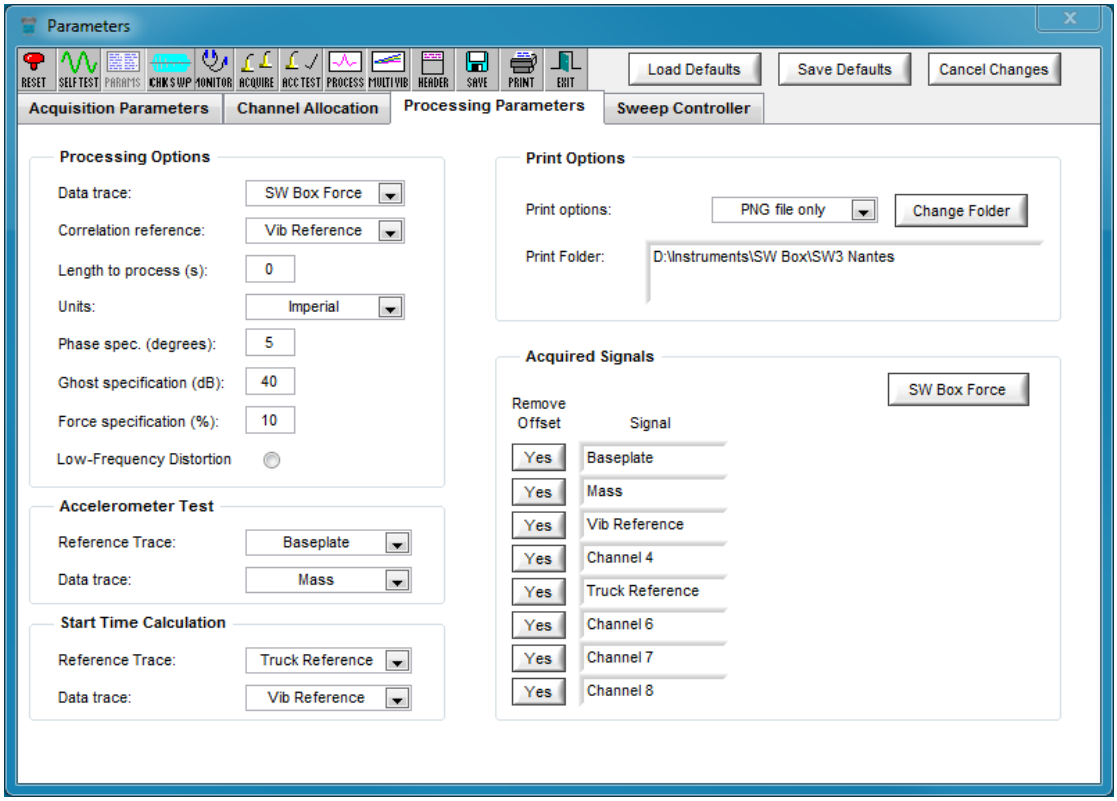
The Input Signal is selected from a pull down menu for each channel that the accelerometer voltage is off. The options on the menu depend on the vibrator electronics type, selected on the Sweep Controller tab. Generally the options

are baseplate or mass acceleration measured by the vib electronics, vibrator force or reference signals or just voltages.

The force and acceleration signals are scaled prior to recording so that they can be compared directly with the Sandwich Box signals.

## Processing Parameters

This tab lists the specifications and channels used by the various processing modules in the software package.




The tab is divided into five areas.

## Processing Options

This module contains the parameters used by the sweep processing and accelerometer test modules.

### Data Trace

This control selects the signal to be analysed by the process module. Normally this would be the Force signal, but other traces may be selected for troubleshooting purposes, e.g. selecting the mass would use the mass acceleration signal.

### Correlation Reference

This selects the trace to be used as the correlation reference during processing. Normally the recording truck reference (correlation reference)

should be selected if it available, otherwise the vibrator reference can be used.

This trace is also analysed to estimate the highest and lowest sweep frequencies and these values are used as the maximum and minimum frequencies on the Phase and Amplitude Spectrum plots.

This form of scaling may not work well with non-linear sweeps so the axes can also be manually scaled using values entered on the Scale page of the processed data.

**Length to Process (s)**

This control selects the length of data to process in seconds; it would normally be set equal to the sweep length. Selecting zero causes the whole record to be processed.

**Units**

This control selects whether pounds or decaNewtons are used to display force results. Note that when an accelerometer signal is chosen as the Data Trace this control also determines whether accelerations are displayed in g or $ms^{-2}$.

**Phase Spec. (degrees)**

This selects the phase specification for the vibrators in degrees – typically this will be between five and ten degrees. Red horizontal cursors will be drawn on all phase plots at this value.

**Ghost Specification (dB)**

This selects the permissible amplitude in decibels below the correlation peak for the correlation ghost. This will be drawn as a red horizontal cursor on the correlation wavelet decibel plots. A typical value for this parameter is 40 dB.

**Force Specification**

This controls the allowable deviation from the target force in percent. Red horizontal cursors are displayed on the force plots to indicate this tolerance.

**Low Frequency Distortion**

This radio button enables a special algorithm for processing sweeps with very low start frequencies (below about 5 Hz). The algorithm reduces leakage between frequency bins after using a Fourier transform in processing. The best way to see if this is a needed is to analyse a reference sweep. If there is significant distortion on the reference sweep that is reduced when the low frequency algorithm is used then the low frequency algorithm should be used when processing vibrator force data.

## Accelerometer Test

This selects two channels to be compared in the Accelerometer Test module. The accelerometer test module allows direct comparison of two similar

accelerometer signals for phase and amplitude difference. A special record should be made with both accelerometers side by side on the mass.

**Reference Trace**

This selects the trace to be used as the reference during processing of an accelerometer test.

**Data Trace**

This control selects the signal to be to be used as the data trace for an accelerometer test. The resulting plots show the result of the data trace compared to the reference, i.e. an amplitude of +2 % means that the amplitude of the data trace is 2 % higher than the reference trace.

## Start Time Calculation

This selects the two traces to be used for start time error calculation. The start time error is the time difference between the reference sweep in the recording truck, and the local reference generated in each vibrator.

The calculated start time error is displayed on the statistics page of the results in microseconds and also on the printable results page.

Normally both the recording truck and vibrator reference signals are recorded on the Sandwich Box to allow the start time error to be calculated. For standalone testing of a vibrator when no recording truck is available the start time error cannot be determined. If either of the two signals is set to No Data, or if the amplitude of either of the two signals is less than one millivolt, the calculation will not be performed.

**Reference Trace**

This selects the trace to be used as the timing reference during processing of a start time test. Normally this would be the correlation reference from the sweep generator in the recording truck. If no recording truck reference is available then No Data should be selected to suppress spurious results.

**Data Trace**

This selects the signal to be to be used as the data trace for start time error calculation, normally the vibrator reference sweep.

The resulting plots show the result of the data trace compared to the reference, i.e. an error of +20 µs means that the data trace is starting twenty microseconds later than the reference trace.

## Print Options

This allows the operator to save processed results as graphics files or send them directly to a printer. Data may be saved in PNG, BMP, JPG or PDF formats.

### Print Folder

This displays the folder in which graphics files will be saved. The user can change the folder by clicking the Change Folder button which enables the user to navigate to a different folder. If the folder location has not been changed the user is prompted to confirm the folder to use the first time a graphics file is saved each time the software is used.

## Acquired Signals

This section selects the signal to be used as the Force signal for sweep processing and also enables offset removal from the processed data.

### Remove Offset

No offset removal is performed on the recorded Sandwich Box signals to preserve DC bias voltages that may be of interest although the analogue outputs on the front panel of the hardware have the offset removed by the output electronics.

In Yes is visible on the Remove Offset buttons then the offset will be removed when the data is processed.

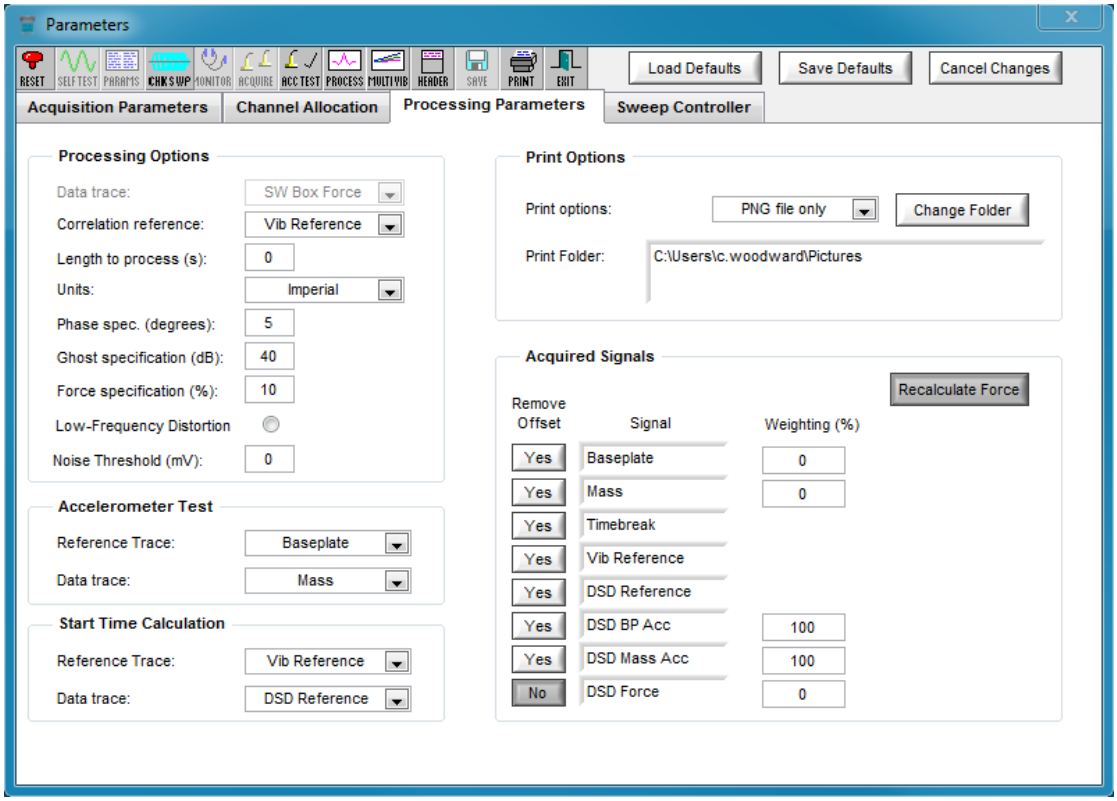
Note that the Sandwich Box accelerometer signals have high level of offset of around 9 volts. It is recommended that the DC offset is removed for all channels.

### SW Box Force/ Recalculate Force

When SW Box Force is displayed the data trace used for processing is one of the nine recorded signals, including the SW Box Force signal which is generated in real time during data acquisition and saved as the ninth data trace. This is the normal method of operation.

Clicking the SW Box Force button changes the test to Recalculate Force which enables a force signal to be generated by the processing module.

When Recalculate Force is displayed the data trace is calculated from one or more of the recorded acceleration or force signals at the time of processing.



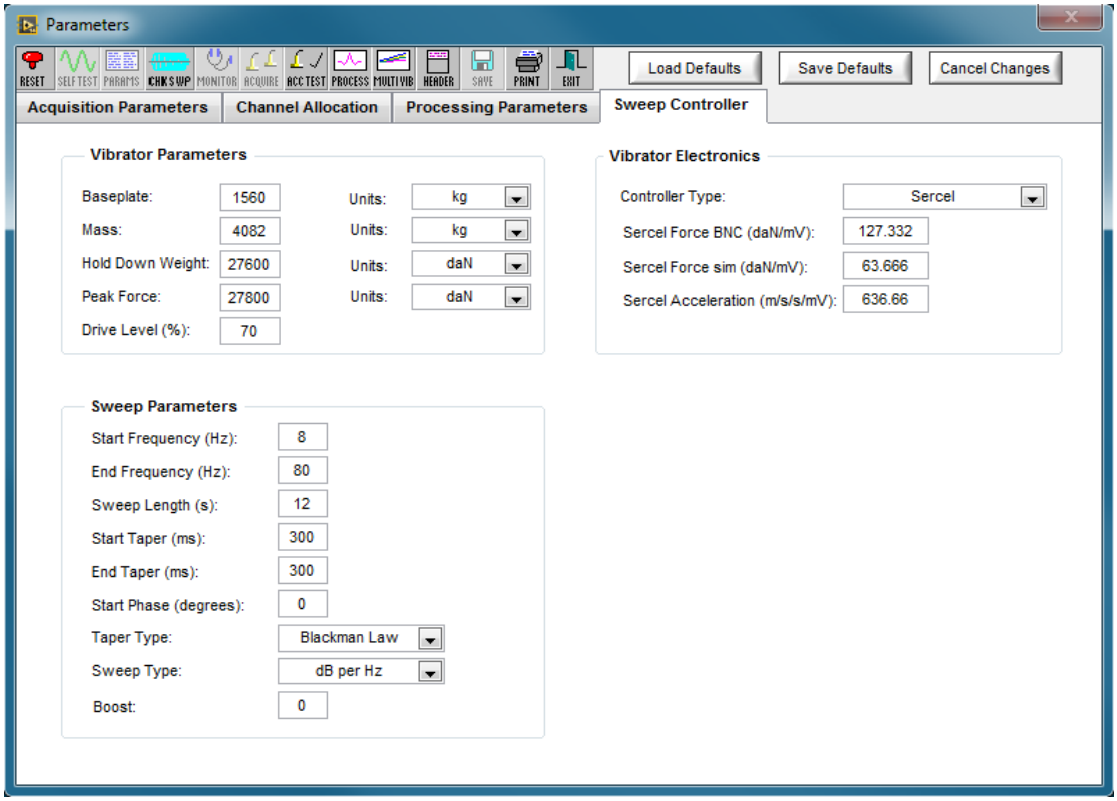

Each acceleration and force signal has a weighting control which can be used to generate a new force signal using a combination of any of the recorded signals. The user should enter a percentage weighting for each of the recorded accelerometer and force signals.

The acceleration signals are automatically multiplied by the mass of the appropriate structure (mass or baseplate) as selected in the Channel Allocation parameters when the data was recorded.

Note that the sum of the weightings for all of the accelerometers connected to each of the mass and baseplate structures or force signals should equal 100 %, as in the example shown above. The user is responsible for ensuring that this is done correctly.

## Sweep Controller

This tab lists the specifications and channels used by the various processing modules in the software package.




The tab is divided into three areas.

## Vibrator Parameters

This section describes the physical characteristics of the vibrator under test.

Units may be entered in Imperial or Metric units or a combination of both. Note that the lesser of Hold Down Weight and Peak Force is used, along with the drive level, to determine the target force. The value of the Peak Force parameter is used to draw a cursor on the on the Mass Force plot.

The System control is used to select the vibrator electronics that was used to control the vibrators. This input also affects the Input Signal options on the Channel Allocation tab, is used to select the signal sensitivities used to scale the Force and Acceleration measurements and is used to calculate the correct target force.

All of these parameters are saved in the Extended Header of the Sandwich Box (SEG-D format) data file so that the correct values are used if the data is processed at a later time. The values in the header can be edited after recording using the View/Edit Header module.

## Sweep Parameters

These controls are not necessary for operation but are used to generate the synthetic sweep if the Check Sweep module is used. They are saved in the Extended Header and can be edited using the View/Edit Header module.

## Signal Sensitivities

These controls are used to enter the sensitivities of the force and acceleration signals output by the vibrator electronics which may be recorded on the Sandwich Box. The sensitivity values are used to scale the signals so that their amplitudes are recorded correctly.

There are different sensitivities stored for each type of vibrator electronics (Sercel, Pelton, Seismic Source and Other).

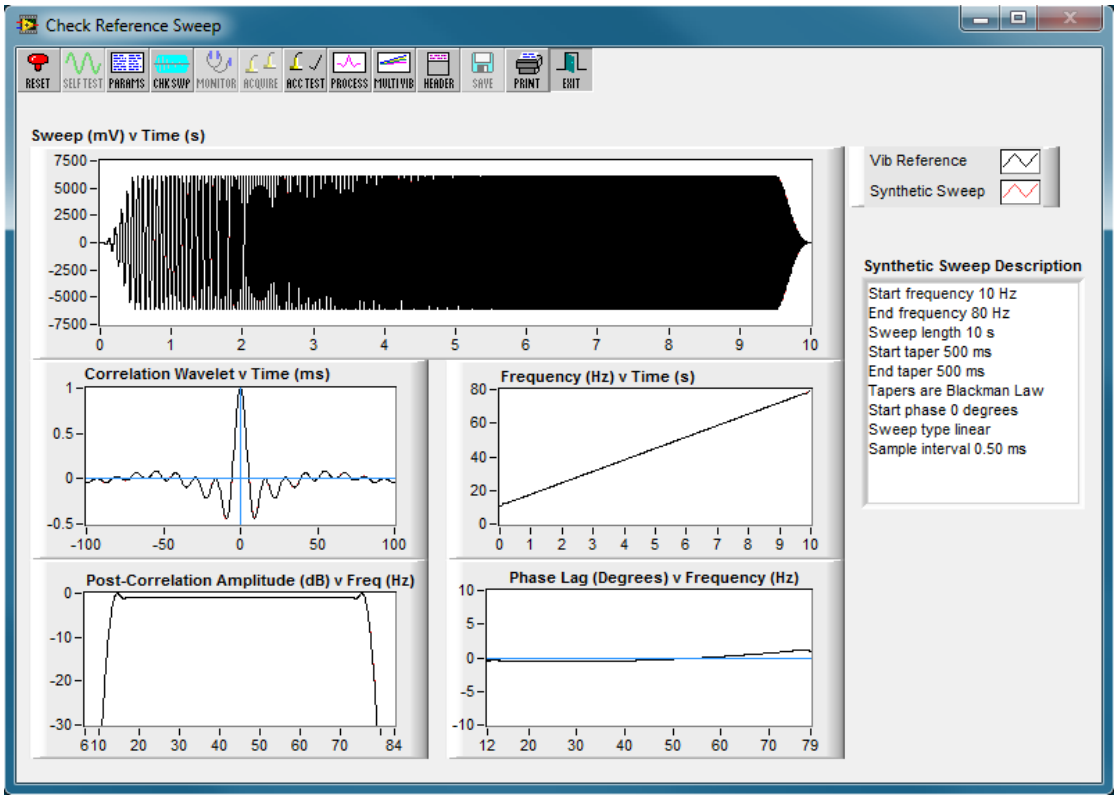
Note that the sensitivity of Sercel force and acceleration signals was changed by patch 20 of software version 2.0. The default sensitivity values shown above apply to all software versions after this.

# Check Sweep

This module compares the recorded reference sweep with a sweep generated in software to check that the sweep parameters are correct. The software sweep is generated using parameters entered on the Sweep Generator Parameters when the recording was made, although these parameters can be retrospectively edited at any time using the View/Edit Header module.

The reference sweep used for the analysis is the correlation reference sweep selected on the Processing Parameters tab.

Standard non-linear sweeps are supported but custom sweeps are not.



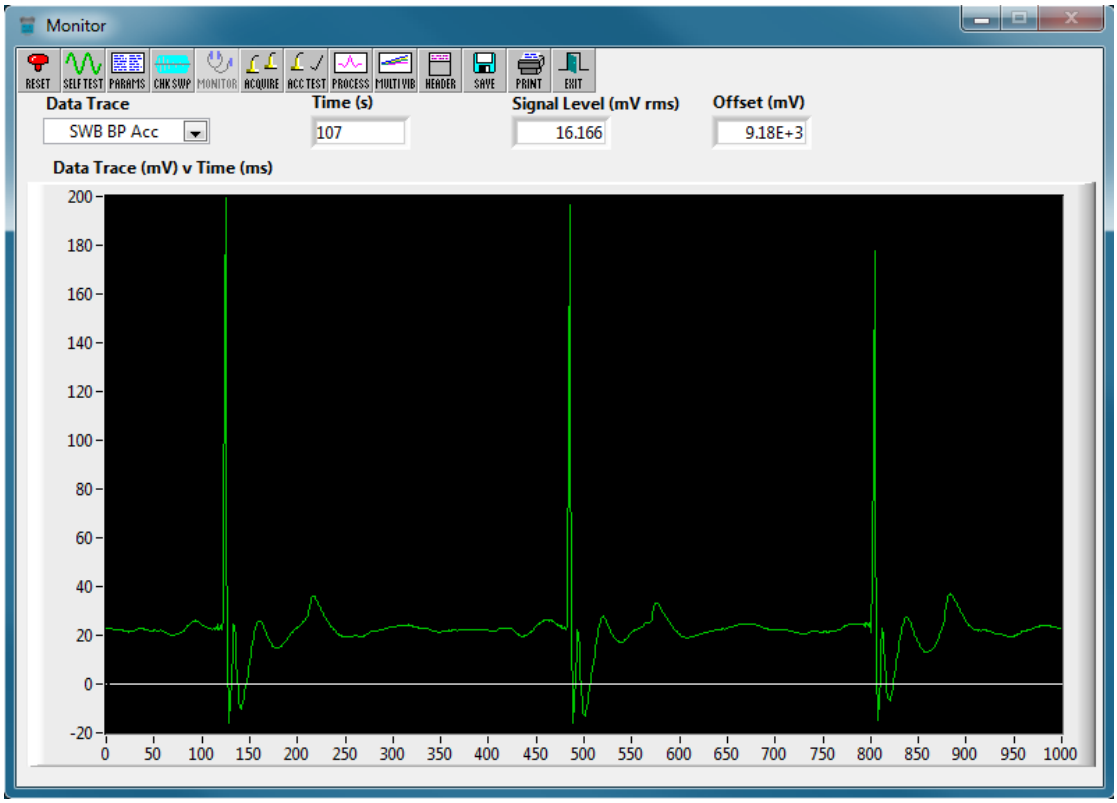

The top plot shows the time series of the sweeps; the synthetic sweep is automatically scaled to match the recorded sweep. The synthetic sweep signal is potted in red and the recorded sweep is displayed on top of it; if the sweeps match perfectly no red should be visible. The correlation wavelet, frequency against time and amplitude plots are similarly displayed with the synthetic sweep in red beneath the recorded sweep. The phase plot shows the phase relationship between the two sweeps.

A summary of the synthetic sweep parameters is displayed to the right of the plots.

# Monitor

The Monitor module displays a real-time display of the signal connected to any one of the eight input channels. The trace being monitored is selected using the drop-down menu of the Data Trace control and the RMS level of the portion of the signal currently displayed on the plot is displayed in millivolts along with the offset voltage that has been removed from the display.

This module may be used to check that all signals are being received correctly and to select a suitable signal and level for the acquisition trigger and noise threshold parameters.

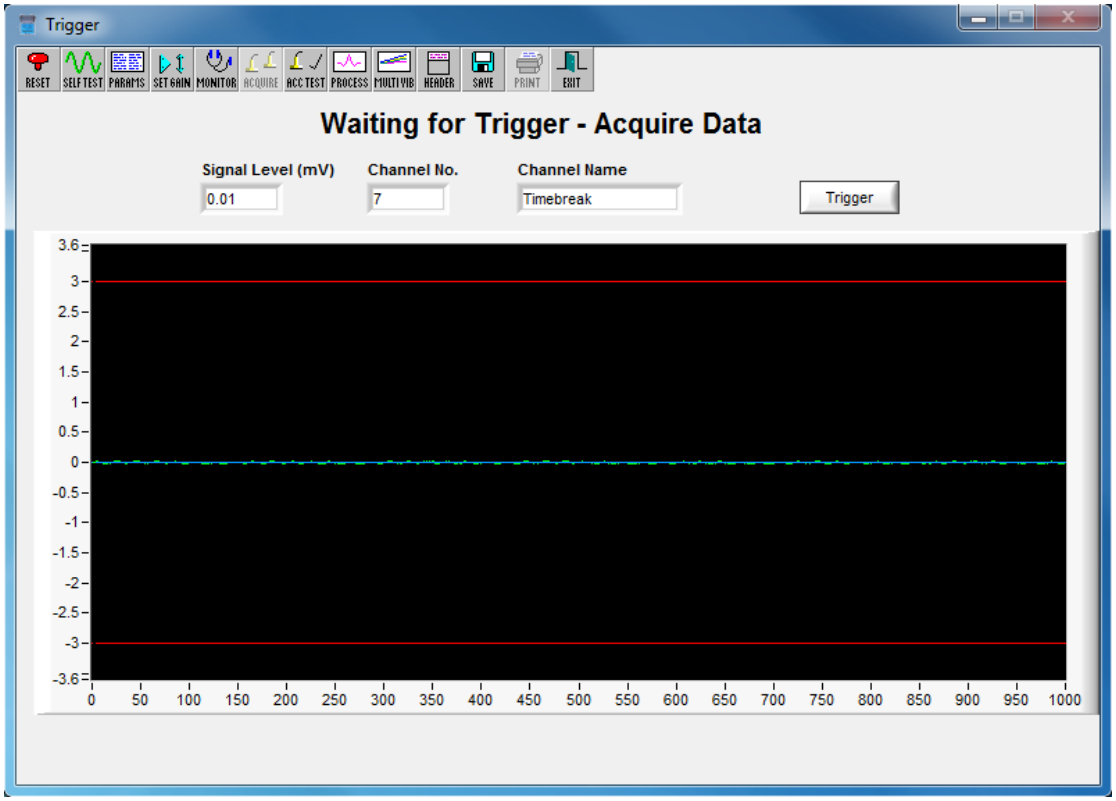


# Acquire

This module acquires data that can be saved on the PC and subsequently processed.

The accelerometers should be placed on the mass and baseplate structures as appropriate. Note that, in order to emulate the vibrator control electronics signals, the Sandwich Box accelerometers should be placed as close as possible to the control system accelerometers.

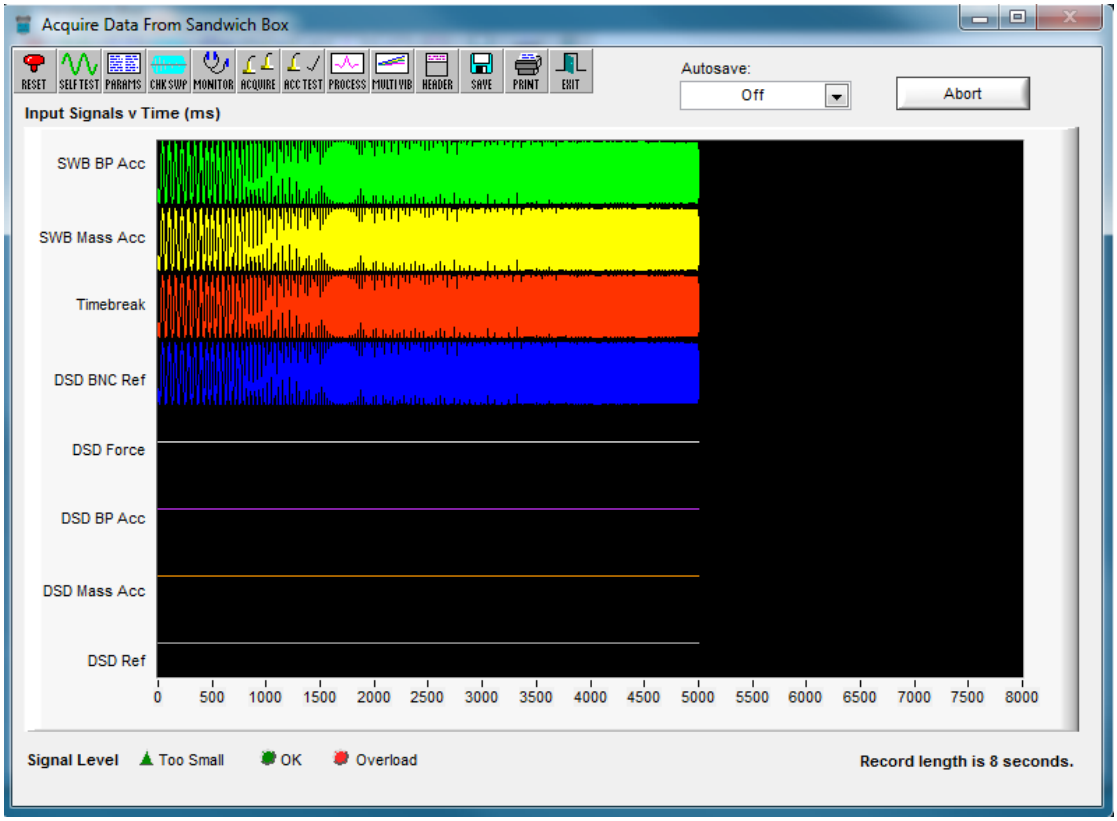
Clicking the Acquire icon causes the Trigger screen to appear. If the trigger is a threshold voltage on an analogue signal then a real time display of the selected Trigger Channel is shown with cursors indicating the selected threshold voltage(s). If a single polarity threshold has been selected in the Acquisition Parameters then only one cursor will be shown.




In this condition the A/D converters are free running and acquisition will start of the first sample after the threshold voltage is reached. Note that subsequent recordings will not necessarily start at exactly the same time resulting in jitter between records, however all signals within each record are sampled at exactly the same time. The Trigger button can be used to initiate a record start irrespective of the threshold level.

If a digital (TTL) trigger is selected than the A/D convertors are switched off until the trigger signal is received at which time the converters are all started. Owing to the digital filters used by the system there is a delay of around 32 samples before the first valid data is received at the output of the filter. The first valid sample is duplicated 31 times to pad the record so that it starts as close as possible to the correct time, although there is no useful data in the first 31 samples. The residual timing delay, caused by the timing delay not

being precisely equal to an integer number of sample intervals, is recorded in the Sample Skew field of the output record so that the true timing can be recovered in processing.

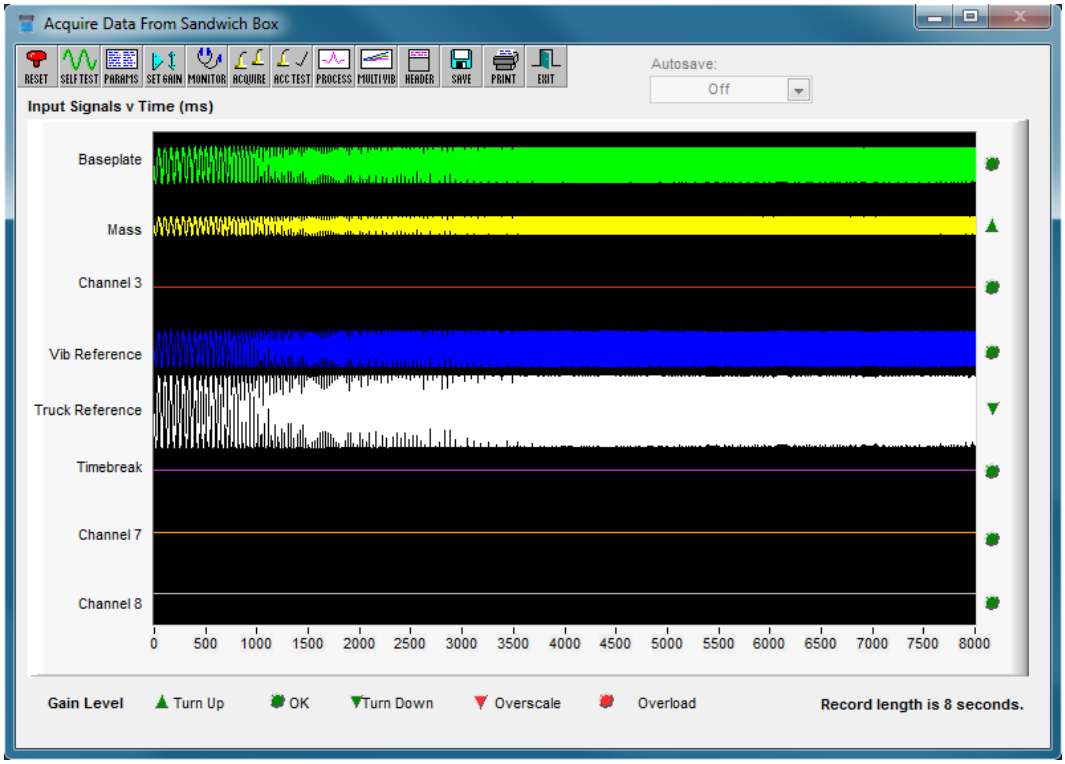



The acquisition display is updated every 500 samples during the acquisition. If the sweep length exceeds 16 seconds the plot scrolls, showing a maximum of 16 seconds of data.

Clicking the Abort button during the sweep terminates the acquisition. Clicking the Autosave control during the acquisition allows the user to change the autosave mode using the drop down menu (see Acquisition Parameters).

This window can be resized or maximised to make better use of high resolution monitors.

At the end of the sweep, gain level symbols are displayed for each trace to the right of the plot. The symbols indicate whether the recorded signals are of appropriate amplitude. As long as the symbols are green the data can be processed – if any trace shows a red symbol then an overscale has occurred on that channel and the data has been clipped and will give erroneous results.




When the acquisition is complete, the data is saved in temporary files in the user's application data folder.

If one of the Autosave options has been selected in the Acquisition Parameters tab then the data will be copied to the user selected Data Folder in the format selected in the File Format control.

If Autosave is not being used then the user can manually save the data by clicking the Save icon, this lets the user add a comment and change the first part of the file name.

Once the data has been saved to the hard disk it can be processed using one of the processing modules.

# Accelerometer Test

This test is designed to check the phase and amplitude response of the accelerometers by comparing them with each other. It is recommended that this be performed each time the unit is set up as it verifies that the accelerometers have been connected correctly and the correct accelerometer sensitivities have been entered in the channel allocation parameters.

*Note that accelerometers are manufactured from piezoelectric crystal and can be damaged by high accelerations, for example if they are allowed to drop onto a structure with a "click." Accelerometers should be placed on the structures one corner first then gently rolled on to it to avoid making a clicking sound.*

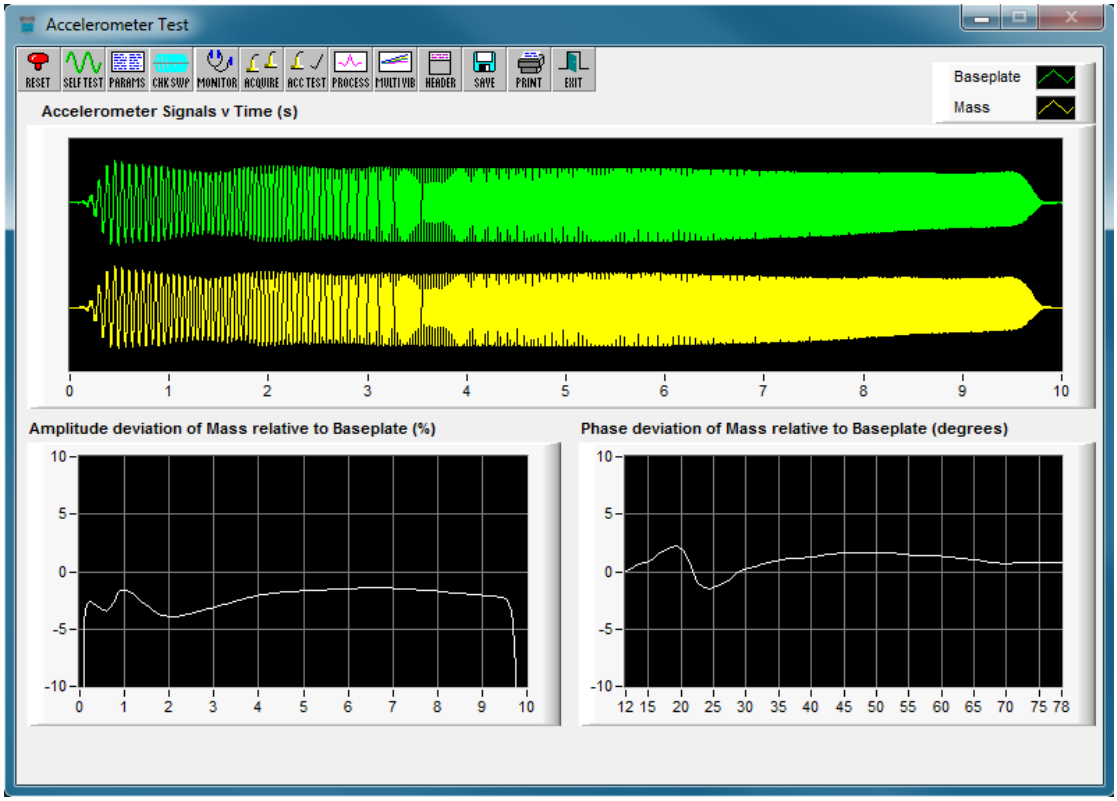
*The magnets should be removed from the accelerometers when not in use to prevent the accelerometers becoming magnetised and affecting the sensitivity.*

To acquire accelerometer test data, both accelerometers should be mounted side by side on the mass, as this generally has less amplitude and phase variation from point to point than the baseplate. The vibrator should then be swept and the data acquired by the Sandwich Box using the Acquire module and saved. The accelerometer test data may then be processed using the accelerometer test module. Alternatively the Sandwich Box accelerometer signals can be compared with the vibrator electronics accelerometer signal if these are recorded on the Sandwich Box.

There is a special section in the processing parameters to select the channels to be compared in the accelerometer test.

Select the Sandwich Box file to process (see Folder and File Selection section of this manual).

The accelerometer test module then compares the amplitude and phase of the selected accelerometer channels and produces the following display:




The top plot shows the raw accelerometer signals and the lower two plots show the amplitude and phase of the Data accelerometer relative to the Reference accelerometer as selected in the Processing Parameters.

Note that there will be some differences between the signals acquired by the two accelerometers as they are measuring the signals in slightly different locations on the mass. In addition accelerometer sensitivity accuracy is typically ±2 % so differences between accelerometers may exceed 4 %. Differences of this magnitude, however, would affect measurements of absolute force and vibrator phase response.

The results of the test may be printed by clicking the Print icon.

# Process

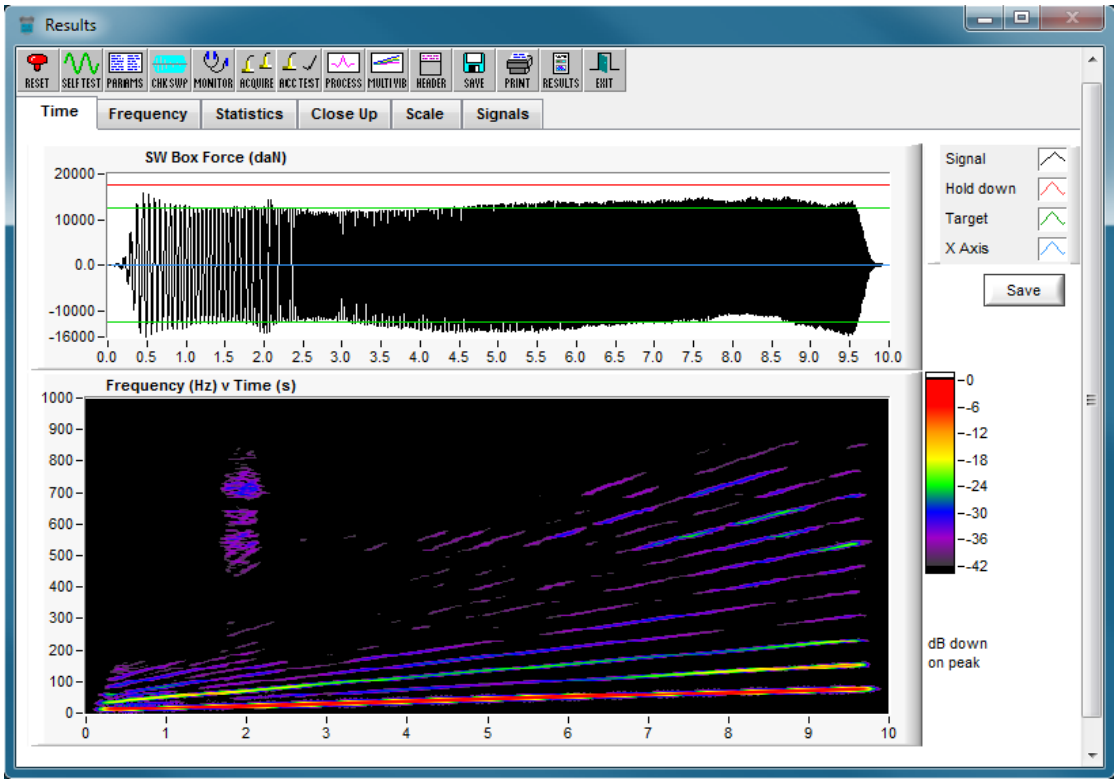
This module analyses data that has previously been recorded by the Sandwich Box.

Executing this module asks the user to select the file to process (see the Folder and File Selection section of this manual) and the file is processed using the values on the processing parameters page and the results are presented on five tabbed pages in the Processing window.

Note: All plots can be rescaled by dragging the cursor over the maximum or minimum value on the X or Y axis and typing in a new value.

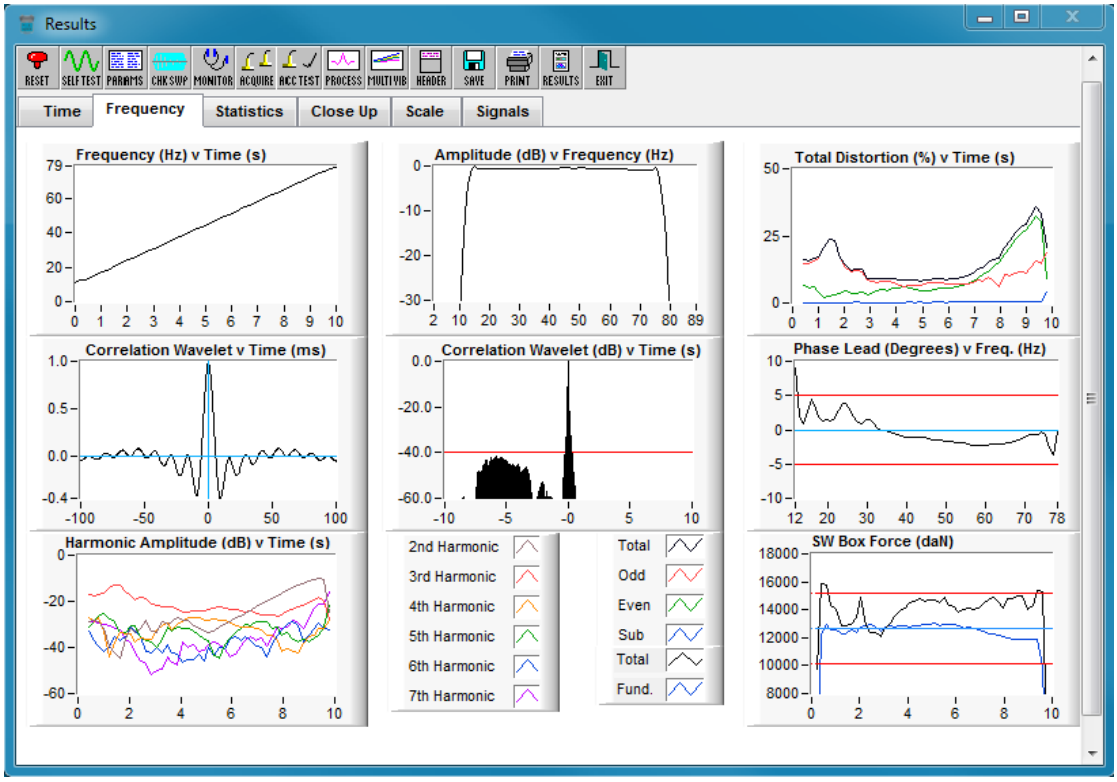
## Time Domain Tab

The first tab, labelled Time Domain, shows trace amplitude and harmonics. The green cursors represent the target force, calculated from the vibrator parameters. The red cursor represents the hold down weight of the vibrator. If the vibrator force signal exceeds the hold down weight there is a possibility that the vibrator is decoupling.




## Frequency Domain Tab

The second tab, labelled Frequency Domain, shows a number of additional plots.




Red cursors on the Correlation Wavelet, Phase and Peak Amplitude plots represent specifications entered by the user in the processing parameters module.

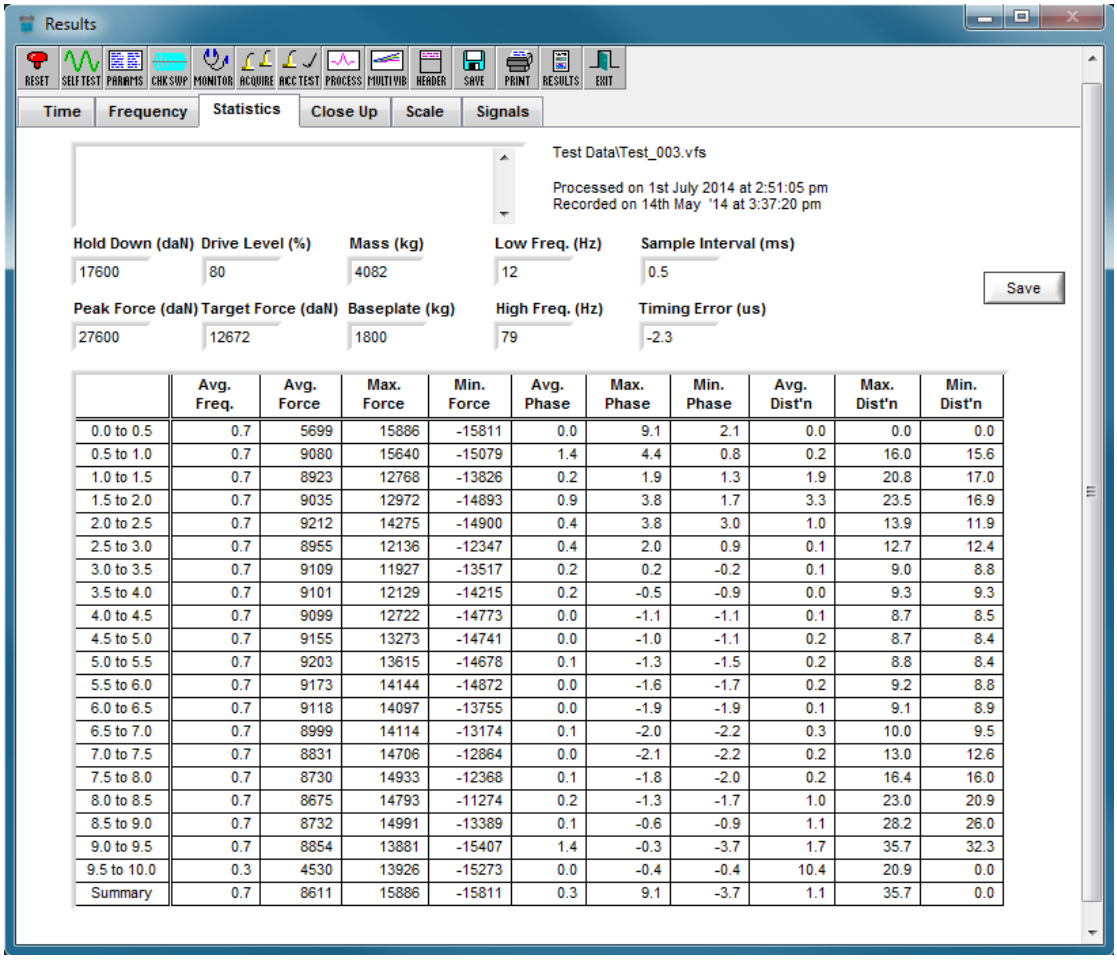
Blue cursors represent the Zero axis for Correlation Wavelet and Phase plots and the Target Peak Force for the Peak Amplitude plot.

The black line on the Distortion (%) graph is the total distortion of the vibrator. The red line is the distortion caused by the odd harmonics (3$^{rd}$, 5$^{th}$ and 7$^{th}$) and the green line is the distortion caused by the even harmonics (2$^{nd}$, 4$^{th}$ and 6$^{th}$). The blue line represents the sub-harmonic distortion, i.e. any energy that occurs below half the fundamental frequency.

The black plot on the Peak Amplitude graph shows the envelope of the raw force signal while the blue plot shows the peak level of the fundamental force signal.

## Statistics

The third tab contains a statistical breakdown of the sweep in either half or one second segments (depending on the sweep length).



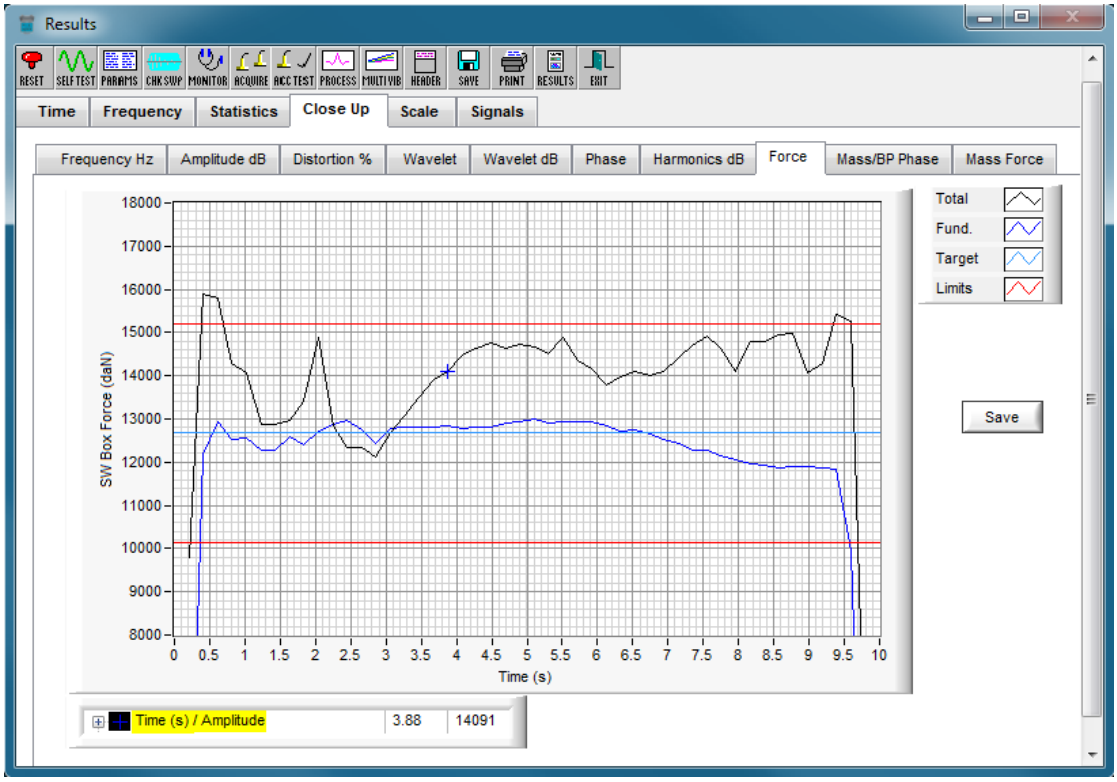

| | Avg. Freq. | Avg. Force | Max. Force | Min. Force | Avg. Phase | Max. Phase | Min. Phase | Avg. Dist'n | Max. Dist'n | Min. Dist'n |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 to 0.5 | 0.7 | 5699 | 15886 | -15811 | 0.0 | 9.1 | 2.1 | 0.0 | 0.0 | 0.0 |
| 0.5 to 1.0 | 0.7 | 9080 | 15640 | -15079 | 1.4 | 4.4 | 0.8 | 0.2 | 16.0 | 15.6 |
| 1.0 to 1.5 | 0.7 | 8923 | 12768 | -13826 | 0.2 | 1.9 | 1.3 | 1.9 | 20.8 | 17.0 |
| 1.5 to 2.0 | 0.7 | 9035 | 12972 | -14893 | 0.9 | 3.8 | 1.7 | 3.3 | 23.5 | 16.9 |
| 2.0 to 2.5 | 0.7 | 9212 | 14275 | -14900 | 0.4 | 3.8 | 3.0 | 1.0 | 13.9 | 11.9 |
| 2.5 to 3.0 | 0.7 | 8955 | 12136 | -12347 | 0.4 | 2.0 | 0.9 | 0.1 | 12.7 | 12.4 |
| 3.0 to 3.5 | 0.7 | 9109 | 11927 | -13517 | 0.2 | 0.2 | -0.2 | 0.1 | 9.0 | 8.8 |
| 3.5 to 4.0 | 0.7 | 9101 | 12129 | -14215 | 0.2 | -0.5 | -0.9 | 0.0 | 9.3 | 9.3 |
| 4.0 to 4.5 | 0.7 | 9099 | 12722 | -14773 | 0.0 | -1.1 | -1.1 | 0.1 | 8.7 | 8.5 |
| 4.5 to 5.0 | 0.7 | 9155 | 13273 | -14741 | 0.0 | -1.0 | -1.1 | 0.2 | 8.7 | 8.4 |
| 5.0 to 5.5 | 0.7 | 9203 | 13615 | -14678 | 0.1 | -1.3 | -1.5 | 0.2 | 8.8 | 8.4 |
| 5.5 to 6.0 | 0.7 | 9173 | 14144 | -14872 | 0.0 | -1.6 | -1.7 | 0.2 | 9.2 | 8.8 |
| 6.0 to 6.5 | 0.7 | 9118 | 14097 | -13755 | 0.0 | -1.9 | -1.9 | 0.1 | 9.1 | 8.9 |
| 6.5 to 7.0 | 0.7 | 8999 | 14114 | -13174 | 0.1 | -2.0 | -2.2 | 0.3 | 10.0 | 9.5 |
| 7.0 to 7.5 | 0.7 | 8831 | 14706 | -12864 | 0.0 | -2.1 | -2.2 | 0.2 | 13.0 | 12.6 |
| 7.5 to 8.0 | 0.7 | 8730 | 14933 | -12368 | 0.1 | -1.8 | -2.0 | 0.2 | 16.4 | 16.0 |
| 8.0 to 8.5 | 0.7 | 8675 | 14793 | -11274 | 0.2 | -1.3 | -1.7 | 1.0 | 23.0 | 20.9 |
| 8.5 to 9.0 | 0.7 | 8732 | 14991 | -13389 | 0.1 | -0.6 | -0.9 | 1.1 | 28.2 | 26.0 |
| 9.0 to 9.5 | 0.7 | 8854 | 13881 | -15407 | 1.4 | -0.3 | -3.7 | 1.7 | 35.7 | 32.3 |
| 9.5 to 10.0 | 0.3 | 4530 | 13926 | -15273 | 0.0 | -0.4 | -0.4 | 10.4 | 20.9 | 0.0 |
| Summary | 0.7 | 8611 | 15886 | -15811 | 0.3 | 9.1 | -3.7 | 1.1 | 35.7 | 0.0 |

Also shown are the vibrator and sweep parameters together with a start time error calculated from start time Data and Reference traces.

This Window has a vertical scroll bar to allow the user to scroll down the table or the Window can be resized.

## Close-Up Plots (General)

Selecting the Close-Up tab allows the user to view the plots individually on a larger scale. The individual plots also contain a grid and a cursor to enable the user to take direct measurements from the graphs. Numerical results of the plotted data may also be saved to a spreadsheet compatible CSV (comma separated value) format.




The indicator below the plot shows the X and Y coordinates of the cursor. The cursor may be dragged to any position on the plot and will stick to the nearest graph when released. If the cursor is not visible, right click on the cursor display and select Bring to Center from the drop down menu.

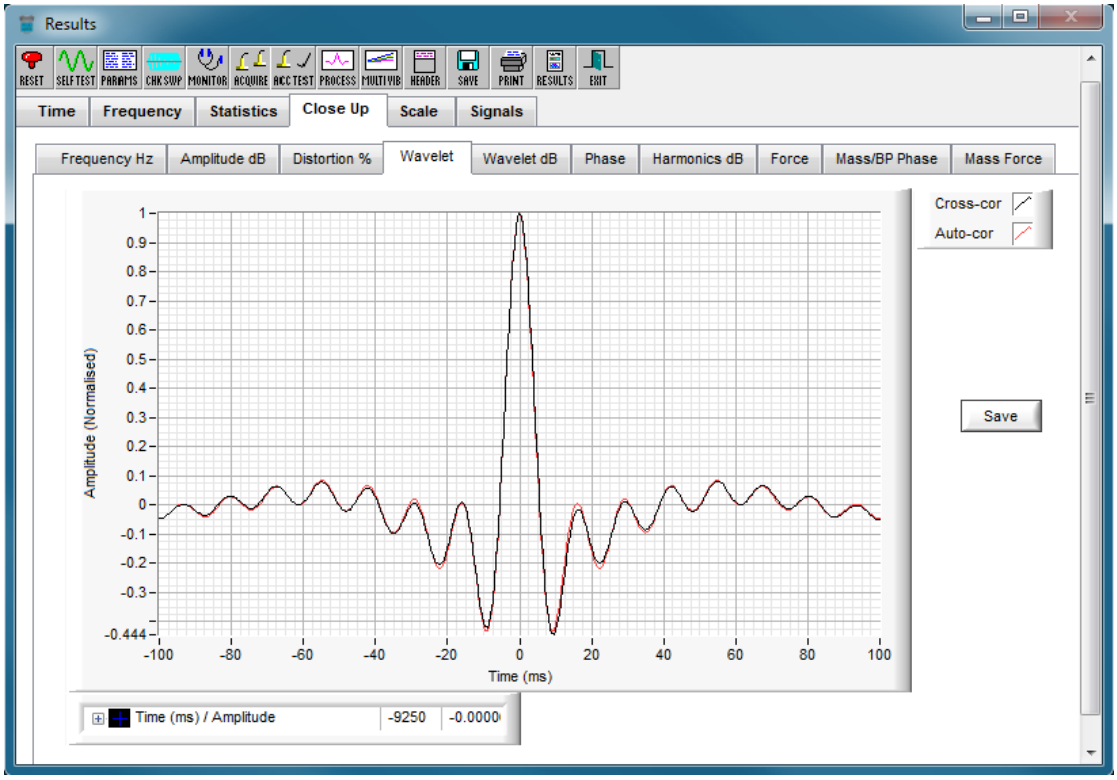
The individual plots may be printed using the print icon or the plot data can be saved in ASCII format by clicking the Save button. Both graphics files and ASCII files are saved in the folder selected on the processing parameters tab. The filenames are automatically generated.

The close up plots include the following additions to the plots displayed on the Results page:

## Wavelet

The wavelet plot shows the centre portion of the normalised correlation wavelet of the data and reference traces, as selected in the processing parameters page.

The close-up plot of this wavelet also shows the autocorrelation wavelet of the reference trace, displayed in red.

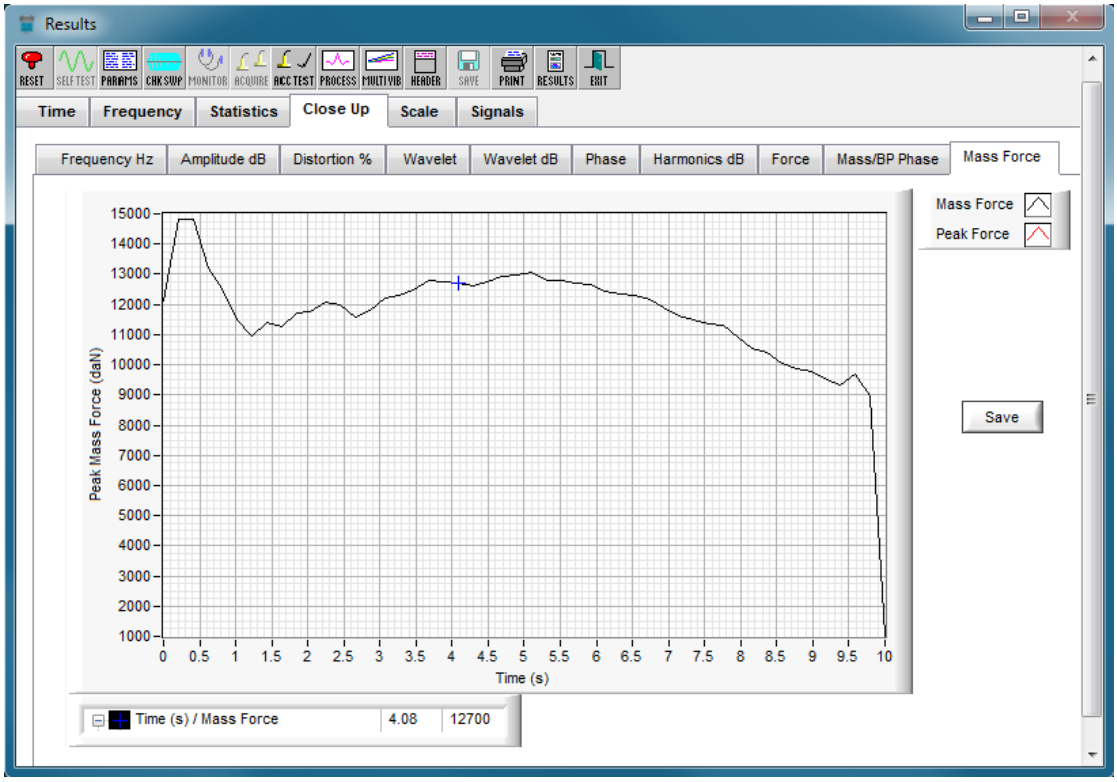



The difference between these wavelets shows the effect of the errors in the data trace on the correlated data.

## Mass Force

The mass force plot is an additional plot which is not shown on the normal results pages. The mass force is the amplitude of the force exerted on the mass calculated from its acceleration multiplied by its mass. The mass force is limited to the vibrator's peak force output although this value may appear to be exceeded as the accelerometer signal is not necessarily representative of the motion of the mass as a whole.

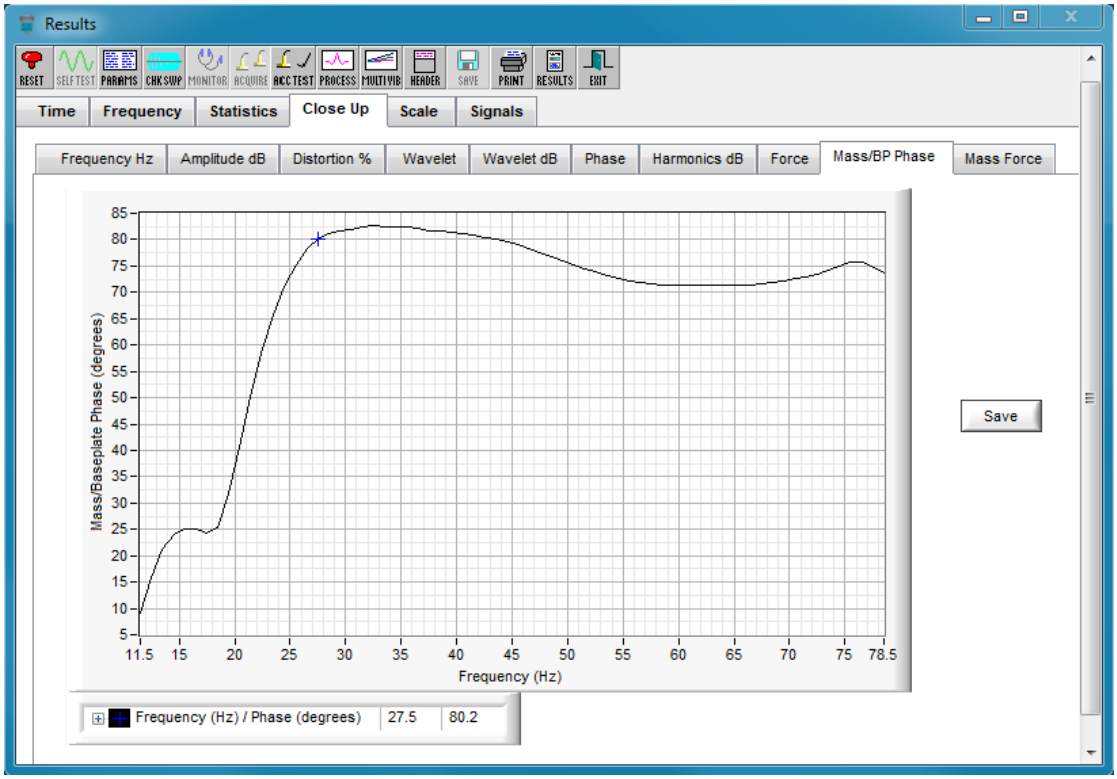
For force locked vibrators the vibrator output (Ground Force) is the sum of the force on the mass and the baseplate structures. The phase difference between the motion of the mass and the baseplate may cause the vibrator's force output to be significantly less than the mass force. The mass force reaching the peak force of the vibrator may be the limiting factor in the maximum output force that the vibrator can achieve.




The red cursor on the plot indicates the vibrator's peak hydraulic force limit, as entered by the user in the acquisition parameters.

## Mass/Baseplate Phase

This plot, which shows the phase relationship between the mass and baseplate structures, is not shown on the normal results pages. The phase relationship between the mass and baseplate becomes important when there is a large phase difference between the two structures, possibly preventing the vibrator from achieving target output force.




Earth/baseplate resonance occurs at the point where there is a 90 degree phase difference between the motion of the mass and the baseplate. The vibrator electronics may have difficulty in controlling the vibrator in this region of the sweep especially if the gradient of the phase plot is steep.

The above two effects are largely determined by the physical properties of the ground on which the vibrator is sweeping and cannot be controlled by the vibrator electronics. This plot can help to explain vibrator behaviour under adverse ground conditions.

## Scale Plots

The scale plots tab allows the user to fix the axes of some of the results graphs to prevent auto-scaling allowing results from different vibrators can be compared more easily.

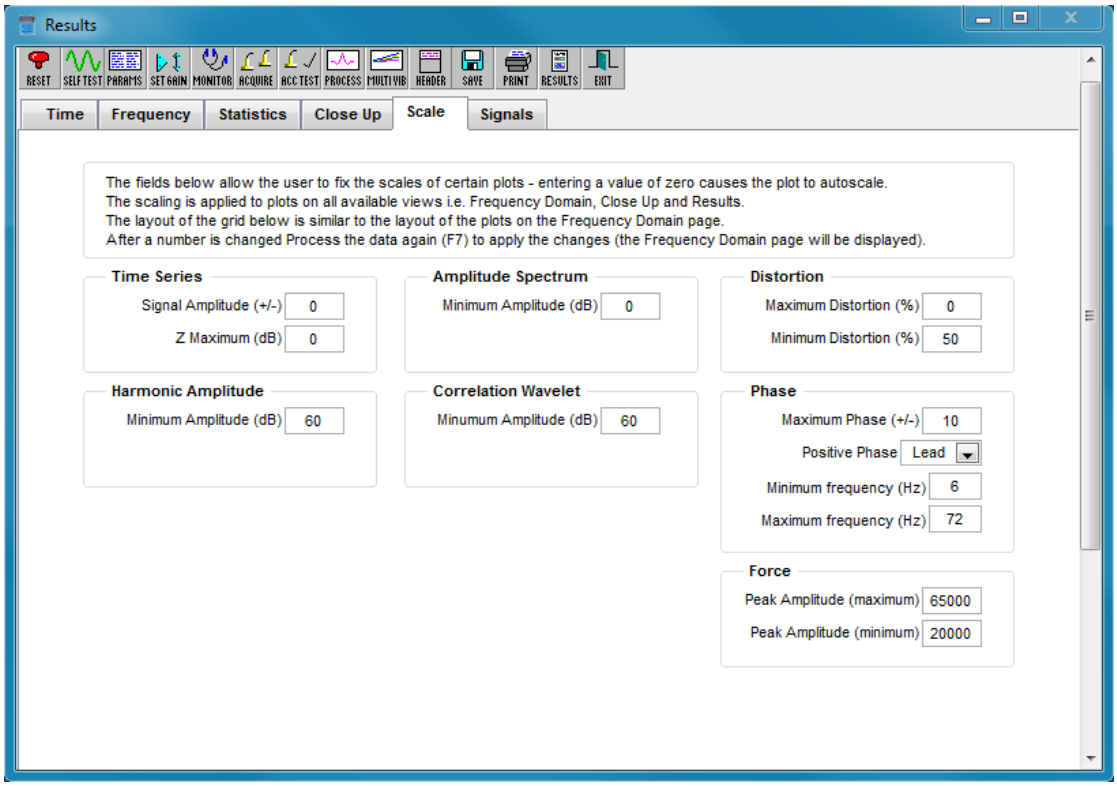
Entering a value of zero allows the plot to auto-scale each time a file is processed (a default value is used for decibel plots).

If a number other than zero is entered then the scale for the selected plot will be fixed in three of the places where the plots are displayed (i.e. frequency domain, close up and print results). Fixed scales are not applied to the Multi Vibrator plots.

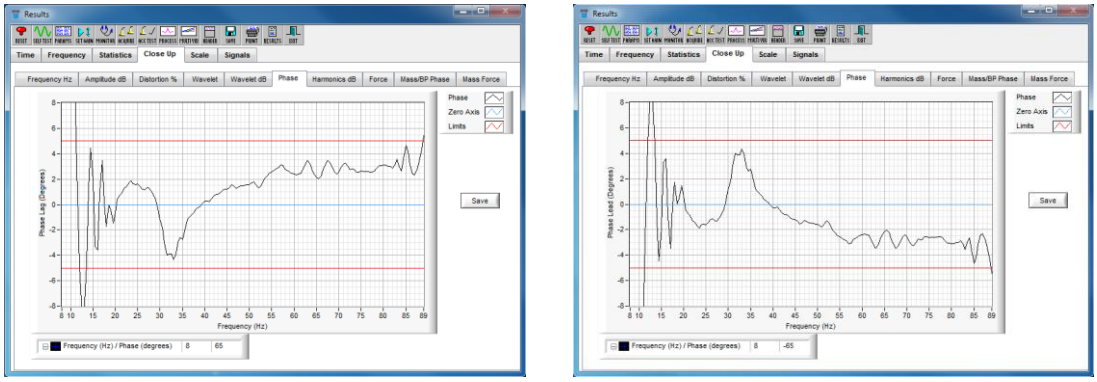
When the value in a control is changed the change is applied the next time a record is processed.

The Amplitude Spectrum and Frequency v Time plots use maximum and minimum sweep frequencies and these are calculated from the frequencies

entered for the Phase plot if these are non-zero or by analysis of the maximum and minimum frequencies in the reference sweep.



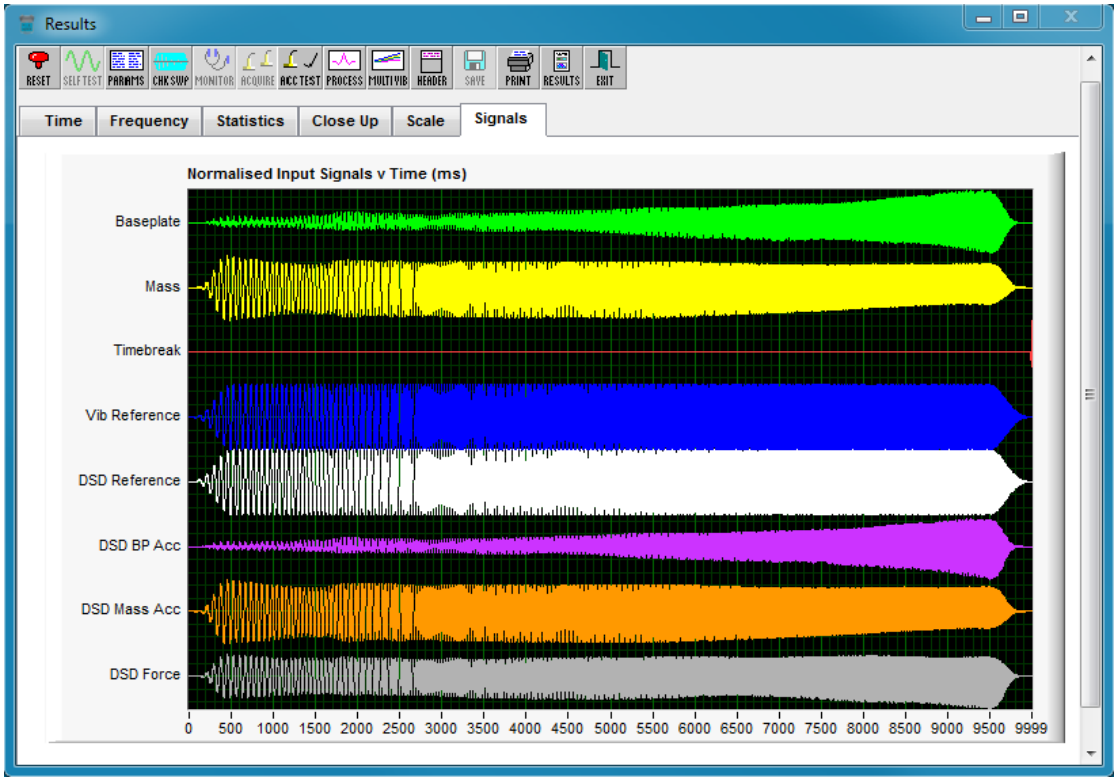

The phase plot may be inverted to plot either a phase lead or phase lag as positive. This enables the display to match the results from other systems as there is no standard for how the phase should be displayed. A positive phase lag means that the Data trace lags the Correlation Reference.



The same phase plot plotted with phase lag (left) and phase lead (right) plotted as positive.

## Signals

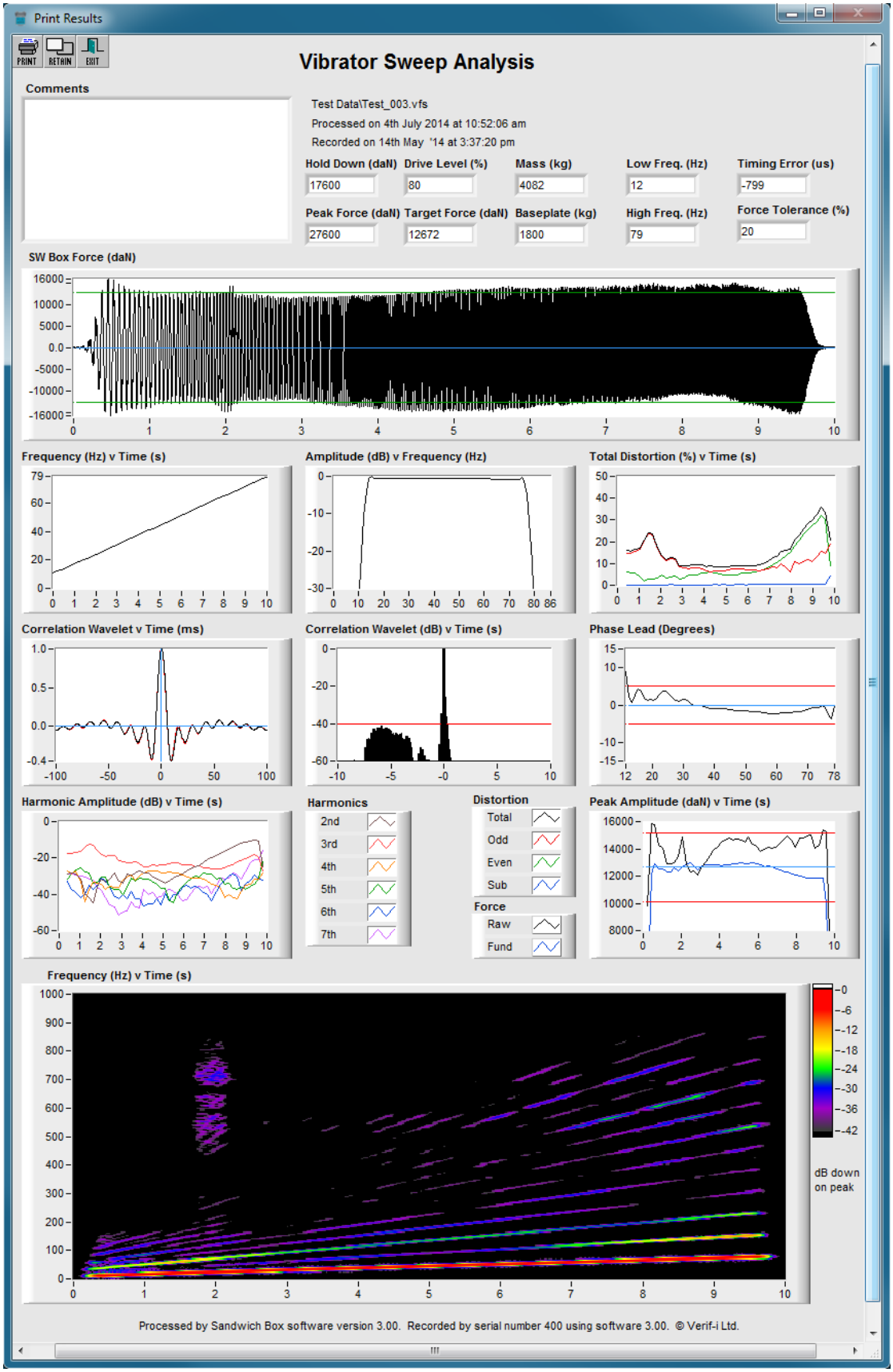
The signals page contains a single plot showing the time series of all signals saved in the Sandwich Box file. The plots are normalised so that each signal fills the same amount of space on the graph without overlapping.




## Results

Clicking the Results icon opens a window containing all plots formatted for printing on a portrait oriented page. The user can rescale the plots prior to printing if required. Plots can be rescaled by highlighting the first or last value on the X or Y axes and typing in a new value or else by editing the values on the Scale tab of the Processing module and reprocessing the file.

Note that the results icon is only available from within the results module.

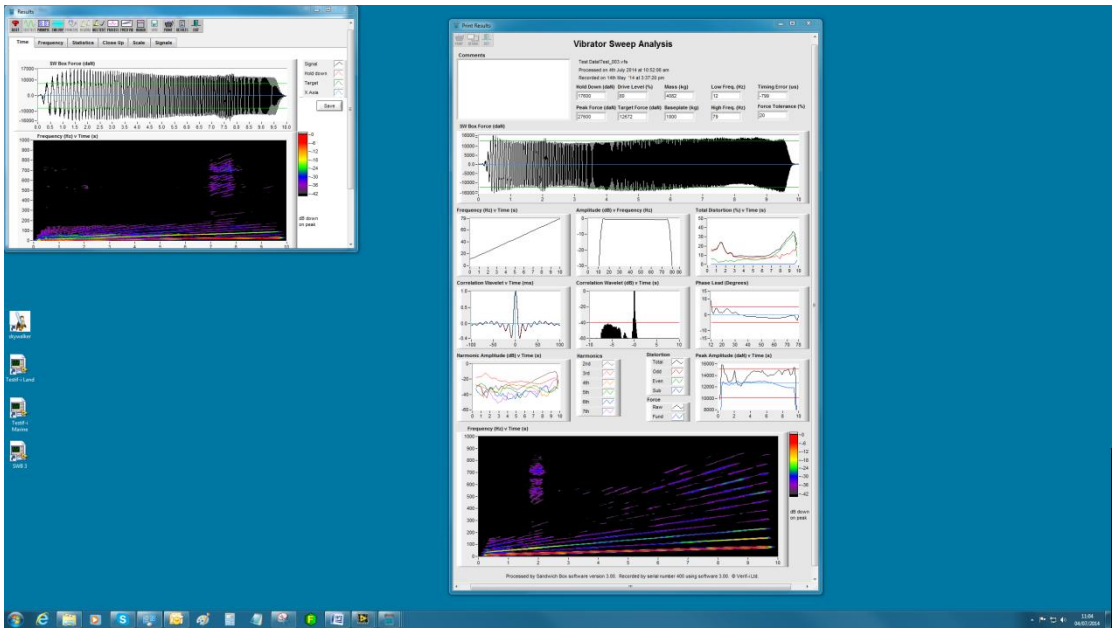



The results page can be resized and positioned by the user by dragging the edges of the Window

Clicking the Print icon saves the results in a graphics file or prints to a printer as determined by the Print Options parameter on the Processing Parameters

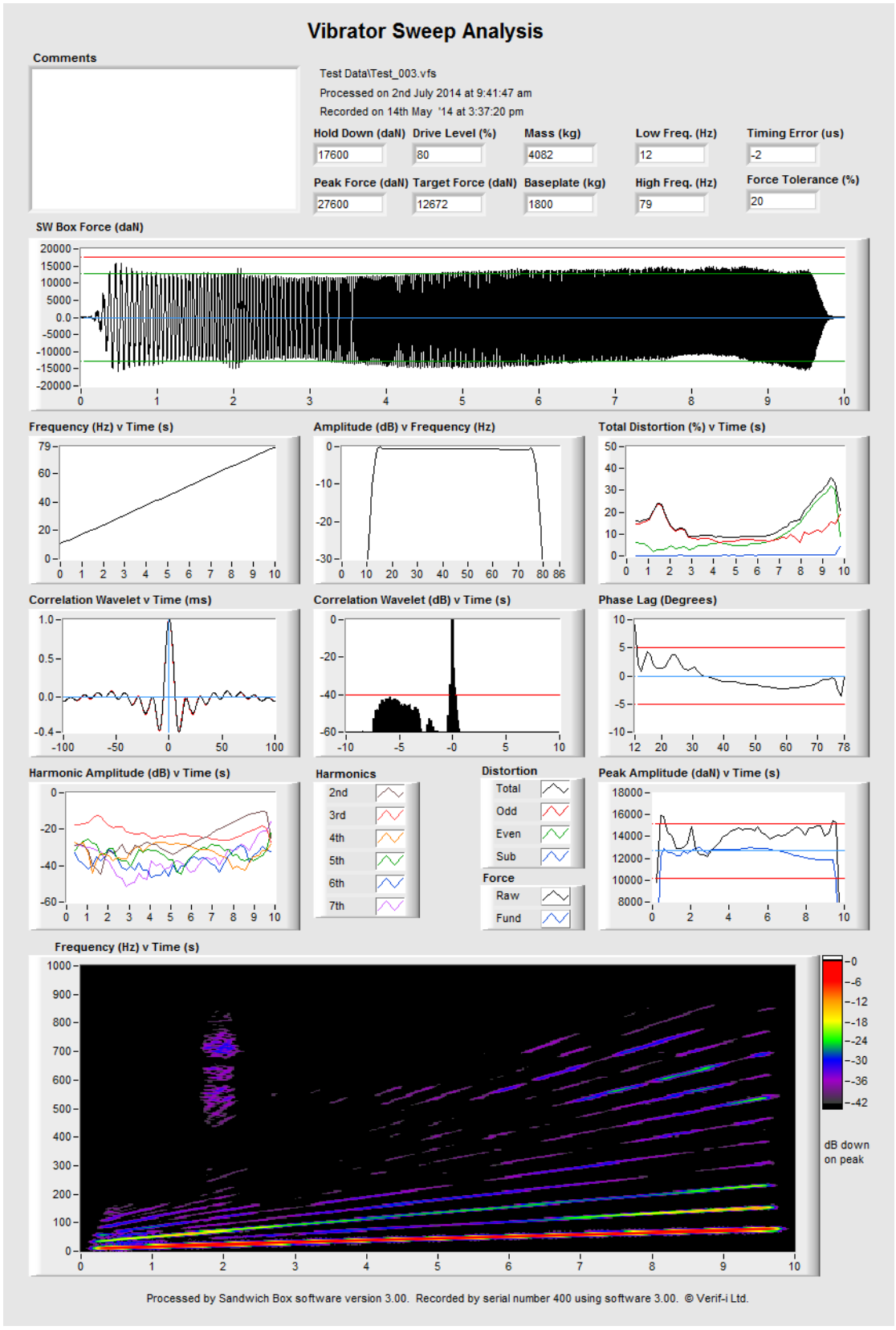
tab. If the results are to be saved the graphics files are automatically named and saved in the user Print Folder selected by the user on the Processing Parameters tab.

The Retain icon is used to return control to the Processing module without closing the Print Results Window. The Print Results Window will remain on the desktop but its icons are greyed out, although the Window can still be closed using the "X" icon on the window title bar. Note that the graphs on the Results Window will not be updated until the Results icon is clicked again.

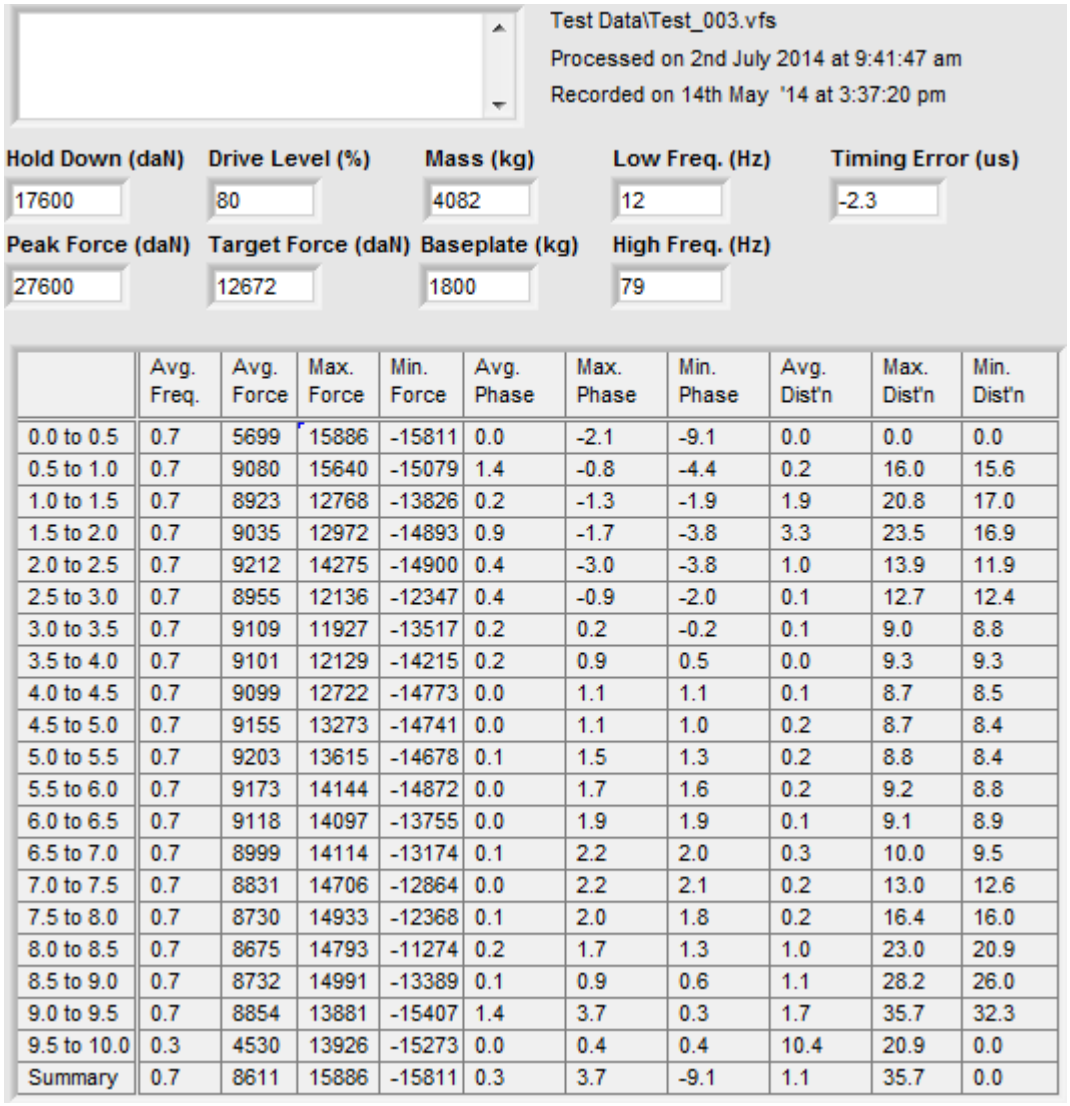



The purpose of this feature is to allow the results of the next tested vibrator to be compared with a previous one.

The Exit icon closes the Print Results Window and returns control to the processing module.




When the Print Results data is printed, vibrator statistics are also printed on a separate page or saved in a separate graphics file using the same graphics format and file name as the plot but with a suffix “stat”.



Test Data\Test_003.vfs
Processed on 2nd July 2014 at 9:41:47 am
Recorded on 14th May '14 at 3:37:20 pm

| Hold Down (daN) | Drive Level (%) | Mass (kg) | Low Freq. (Hz) | Timing Error (us) |
|---|---|---|---|---|
| 17600 | 80 | 4082 | 12 | -2.3 |

| Peak Force (daN) | Target Force (daN) | Baseplate (kg) | High Freq. (Hz) |
|---|---|---|---|
| 27600 | 12672 | 1800 | 79 |

| | Avg. Freq. | Avg. Force | Max. Force | Min. Force | Avg. Phase | Max. Phase | Min. Phase | Avg. Dist'n | Max. Dist'n | Min. Dist'n |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 to 0.5 | 0.7 | 5699 | 15886 | -15811 | 0.0 | -2.1 | -9.1 | 0.0 | 0.0 | 0.0 |
| 0.5 to 1.0 | 0.7 | 9080 | 15640 | -15079 | 1.4 | -0.8 | -4.4 | 0.2 | 16.0 | 15.6 |
| 1.0 to 1.5 | 0.7 | 8923 | 12768 | -13826 | 0.2 | -1.3 | -1.9 | 1.9 | 20.8 | 17.0 |
| 1.5 to 2.0 | 0.7 | 9035 | 12972 | -14893 | 0.9 | -1.7 | -3.8 | 3.3 | 23.5 | 16.9 |
| 2.0 to 2.5 | 0.7 | 9212 | 14275 | -14900 | 0.4 | -3.0 | -3.8 | 1.0 | 13.9 | 11.9 |
| 2.5 to 3.0 | 0.7 | 8955 | 12136 | -12347 | 0.4 | -0.9 | -2.0 | 0.1 | 12.7 | 12.4 |
| 3.0 to 3.5 | 0.7 | 9109 | 11927 | -13517 | 0.2 | 0.2 | -0.2 | 0.1 | 9.0 | 8.8 |
| 3.5 to 4.0 | 0.7 | 9101 | 12129 | -14215 | 0.2 | 0.9 | 0.5 | 0.0 | 9.3 | 9.3 |
| 4.0 to 4.5 | 0.7 | 9099 | 12722 | -14773 | 0.0 | 1.1 | 1.1 | 0.1 | 8.7 | 8.5 |
| 4.5 to 5.0 | 0.7 | 9155 | 13273 | -14741 | 0.0 | 1.1 | 1.0 | 0.2 | 8.7 | 8.4 |
| 5.0 to 5.5 | 0.7 | 9203 | 13615 | -14678 | 0.1 | 1.5 | 1.3 | 0.2 | 8.8 | 8.4 |
| 5.5 to 6.0 | 0.7 | 9173 | 14144 | -14872 | 0.0 | 1.7 | 1.6 | 0.2 | 9.2 | 8.8 |
| 6.0 to 6.5 | 0.7 | 9118 | 14097 | -13755 | 0.0 | 1.9 | 1.9 | 0.1 | 9.1 | 8.9 |
| 6.5 to 7.0 | 0.7 | 8999 | 14114 | -13174 | 0.1 | 2.2 | 2.0 | 0.3 | 10.0 | 9.5 |
| 7.0 to 7.5 | 0.7 | 8831 | 14706 | -12864 | 0.0 | 2.2 | 2.1 | 0.2 | 13.0 | 12.6 |
| 7.5 to 8.0 | 0.7 | 8730 | 14933 | -12368 | 0.1 | 2.0 | 1.8 | 0.2 | 16.4 | 16.0 |
| 8.0 to 8.5 | 0.7 | 8675 | 14793 | -11274 | 0.2 | 1.7 | 1.3 | 1.0 | 23.0 | 20.9 |
| 8.5 to 9.0 | 0.7 | 8732 | 14991 | -13389 | 0.1 | 0.9 | 0.6 | 1.1 | 28.2 | 26.0 |
| 9.0 to 9.5 | 0.7 | 8854 | 13881 | -15407 | 1.4 | 3.7 | 0.3 | 1.7 | 35.7 | 32.3 |
| 9.5 to 10.0 | 0.3 | 4530 | 13926 | -15273 | 0.0 | 0.4 | 0.4 | 10.4 | 20.9 | 0.0 |
| Summary | 0.7 | 8611 | 15886 | -15811 | 0.3 | 3.7 | -9.1 | 1.1 | 35.7 | 0.0 |

This shows a retained Results Window. Note that the icons on the Results Window are greyed out but the Window can be closed using the Operating System controls at the top right corner of the Window.

# Multi-Vibrator Processing

This module may be used to superimpose plots from a number of vibrators on the same graphs. This is useful for a comparison of a number of different vibrators or sweeps.

When the module is launched it will show blank plots. Sweep data can be added and will be saved even when the module is exited unless it is specifically deleted by the user allowing vibrators to be tested and their results added to the Multi Plot module one at a time.

Only the envelope of the Correlation Wavelet (dB) plot is shown for clarity.

This module contains a number of unique icons as well as two normal ones. The icons are shown below with a short description. The underlined words are the hot keys to execute the function using the keyboard.


**Page Up** Adds another sweep to the multi vibrator analysis.


**Page Down** Deletes the last sweep from the multi-vibrator analysis.


**End** Clears all data from the multi-vibrator analysis plots.


**F12** Prints the current window to printer or graphics file.


**Insert** Returns to the main menu but leaves this Window open.

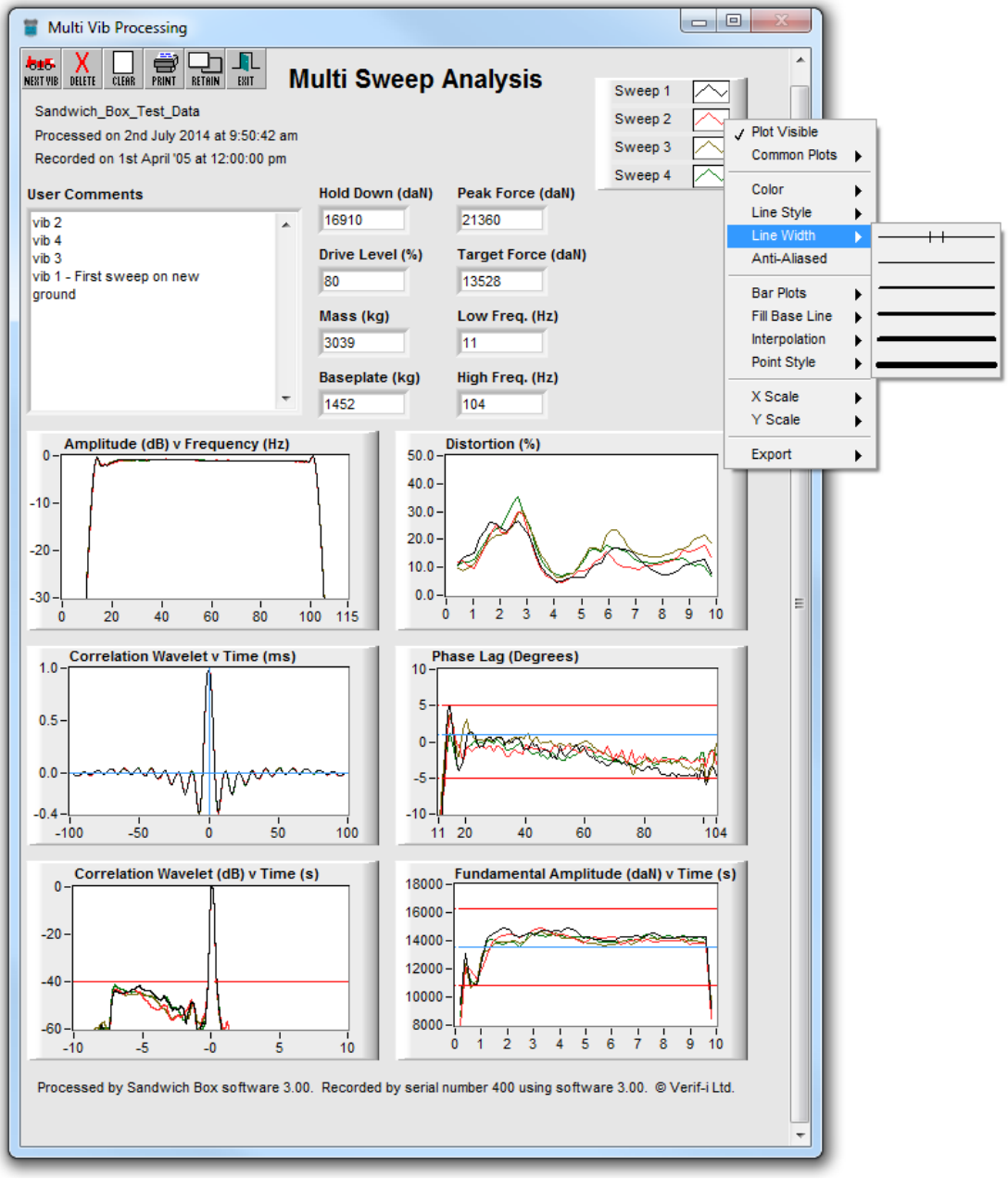

**Exit** Closes this Window and returns to the main menu.

Clicking the Next Vib icon allows the user to add a sweep to the plots. The user should select the first file for processing, see the Folder and File Selection section of this manual.

The data is processed and plotted in black on the graphs. The first line of user comments (or the first 40 characters if shorter) is displayed in the User Comments indicator.

After a sweep has been processed the user has six options:

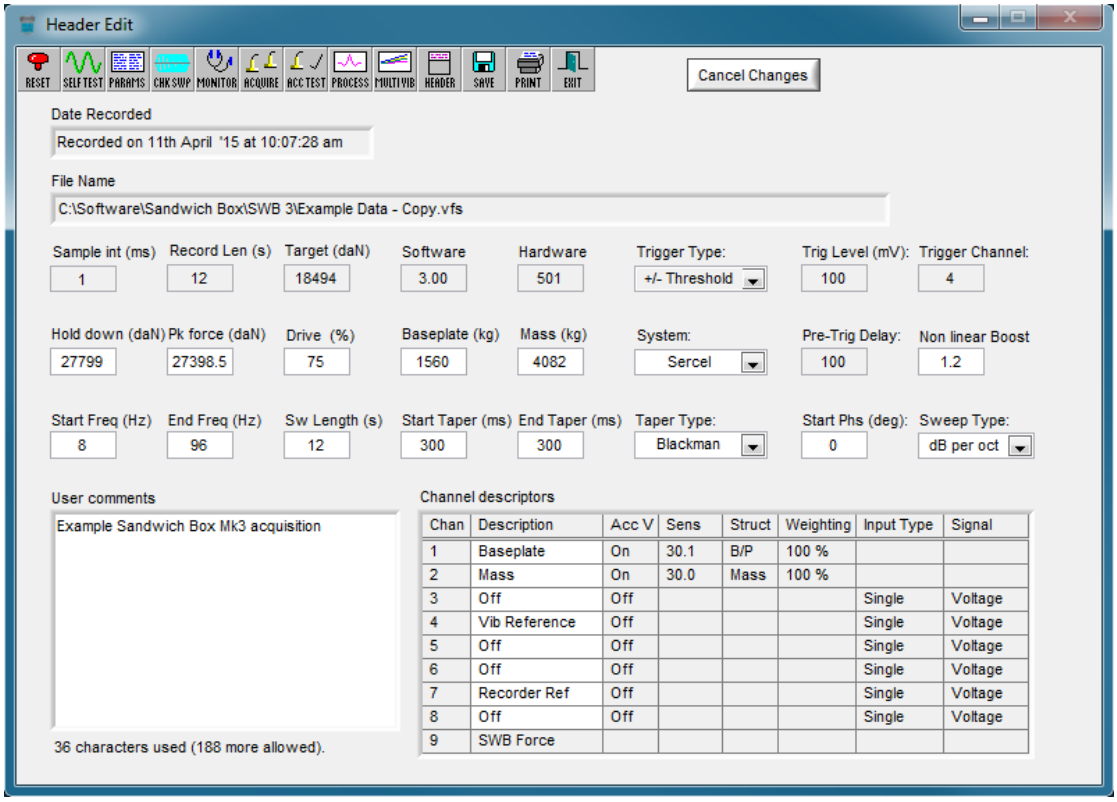
1. Add data from another sweep using the Next Vib icon. The next sweep will be plotted in a different colour on the plots.
2. Delete the last sweep added using the Delete icon.
3. Delete all currently displayed sweeps using the Clear icon.
4. Print the currently displayed data to a printer or graphics file.
5. Return to the main menu leaving the multi sweep analysis window open using the Retain icon.
6. Close the multi sweep analysis window and return to the main menu using the Exit icon.




Individual sweeps can be highlighted by right clicking one of the traces in the legend and selecting enhancements, such as line style, colour and thickness, interactively.

# View/Edit Header

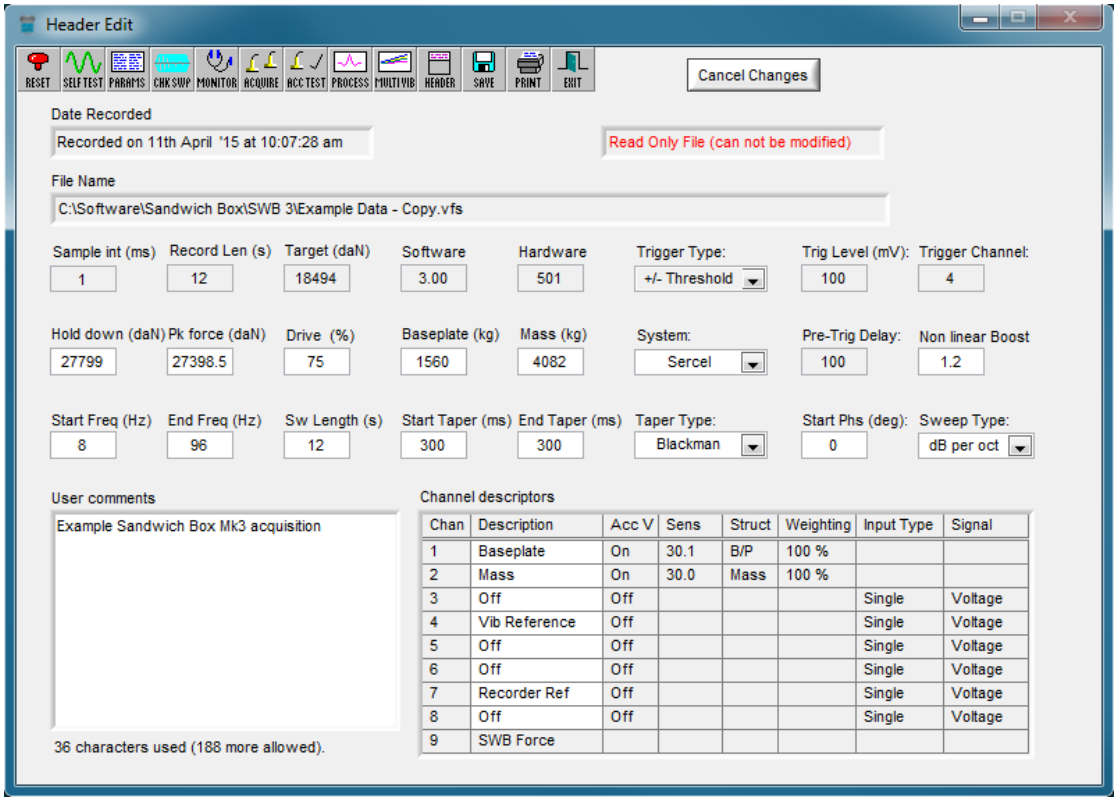
This module allows the user to view data recorded in the Sandwich Box data header. This includes vibrator parameters, channel allocation values and user comments.




Values displayed in fields with a white background can be edited, this includes the user comments. Exiting the module saves the changes to the record header. There is room in the format for 224 characters of user comments, any extra characters will be truncated when the record is saved. There is a display of the number of characters in the user comments at the bottom of the user comment field. This number is continuously updated as characters are typed.

*Changing the mass of the mass or baseplate will affect the force calculation. The computed force channel is calculated at the time the data is recorded and will not change to reflect new values of mass and baseplate entered in this module. If the mass of the mass or baseplate are changed it is necessary to use the Recalculate Force option in the Processing Parameters module to reflect the changes made.*

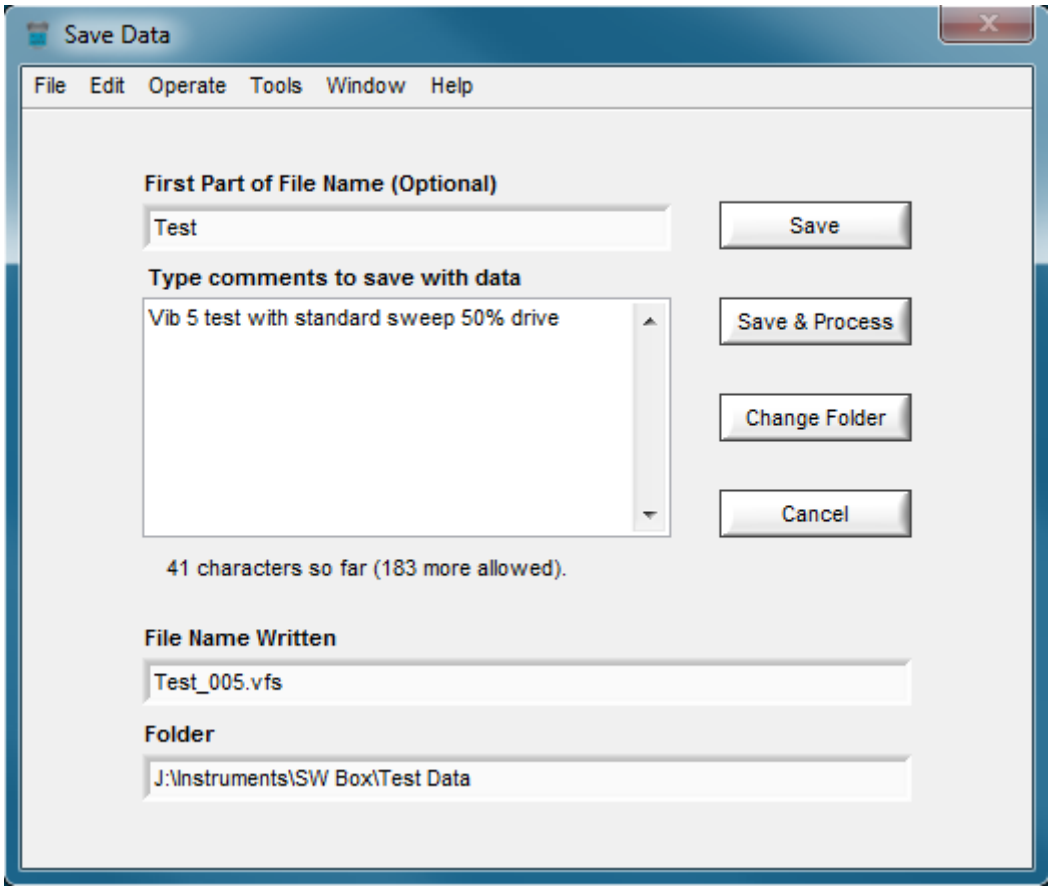
If this module is run on a read only file (for example a file on a CD) a warning will be displayed as edited values cannot be saved.


Header Edit
RESET
SELF TEST
PARAMS
CHK SWP
MONITOR
ACQUIRE
ACC TEST
PROCESS
MULTI VIB
HEADER
SAVE
PRINT
EXIT
Cancel Changes
Date Recorded
Recorded on 11th April '15 at 10:07:28 am
Read Only File (can not be modified)
File Name
C:\Software\Sandwich Box\SWB 3\Example Data - Copy.vfs
Sample int (ms) 1
Record Len (s) 12
Target (daN) 18494
Software 3.00
Hardware 501
Trigger Type: +/- Threshold
Trig Level (mV): 100
Trigger Channel: 4
Hold down (daN) 27799
Pk force (daN) 27398.5
Drive (%) 75
Baseplate (kg) 1560
Mass (kg) 4082
System: Sercel
Pre-Trig Delay: 100
Non linear Boost 1.2
Start Freq (Hz) 8
End Freq (Hz) 96
Sw Length (s) 12
Start Taper (ms) 300
End Taper (ms) 300
Taper Type: Blackman
Start Phs (deg): 0
Sweep Type: dB per oct
User comments
Example Sandwich Box Mk3 acquisition
36 characters used (188 more allowed).
Channel descriptors
Chan Description Acc V Sens Struct Weighting Input Type Signal
1 Baseplate On 30.1 B/P 100 %
2 Mass On 30.0 Mass 100 %
3 Off Off Single Voltage
4 Vib Reference Off Single Voltage
5 Off Off Single Voltage
6 Off Off Single Voltage
7 Recorder Ref Off Single Voltage
8 Off Off Single Voltage
9 SWB Force

## Save

All Sandwich Box data is saved in a folder of the user's choosing. See the Folder and File Selection section of this manual. The Change Folder button can be used to change the currently selected folder.

Once the folder has been selected the user is prompted to enter information to be saved with the data.




The first field is a space where the user can optionally enter a text string which will be used as the first part of the file name used to store the data.

The user can enter comments of up to 224 ASCII characters in the second field. If a longer message than this is entered it will be truncated to 224 characters before being saved. When Autosave is on the last comment entered (if any) will be used for all subsequently saved files. Note that comments can be retrospectively edited using the Header Edit module.

These comments are shown in the processing modules, when the user is prompted to choose a file to analyse, to aid file selection and are printed on the results pages of processed data.

Clicking the Save button saves the last acquired sweep data to disk as a SEG-D format Sandwich Box format file (file extension VFS) and additionally as a SEG-Y or Testif-i format file if this has been selected on the Parameters/Acquisition tab.

The second part of the filename is a three digit number starting at 000 and incrementing by 1 each time a file is saved. This is done automatically by the software.

Selecting Save & Process saves the record, as described above, and then launches the processing module to process the record.

## Print

Selecting the Print icon either prints the currently visible window or saves it as a graphics file, depending on the selected print option in the processing parameters.

When the first graphics file is saved the user is prompted to select a folder in which to save the data. The filename is generated automatically in the format xxxxaaaa.fff. Subsequently saved graphics files are saved in the same folder.

xxxx is a four digit number which is incremented by one for each saved file.

aaaa is a four character code indicating the modules used to generate the file.

fff is the file extension indicating the file format (png, jpg, bmp or pdf).

The character codes are as follows:

| | |
|---|---|
| main | Front panel |
| self | Self test |
| para | Parameters |
| chck | Check sweep |
| moni | Monitor |
| acqu | Acquire |
| acct | Accelerometer test |
| proc | Processing module |
| sing | Single vibrator results page |
| stat | Vibrator statistics |
| mult | Multi vibrator plot |
| head | Header |

## Exit

Clicking the Exit icon within any module closes the module window and returns to the main menu. Exiting from main menu saves the current acquisition and processing parameters to disk then closes the Sandwich Box programme.

# Troubleshooting

There are two status LEDs on the front panel of the Sandwich Box. The red LED, labelled Power, is lit whenever the Sandwich Box is switched on and power is applied to the unit. If this LED does not light then check the power supply and fuse.

During data transfer between the Sandwich Box and the controlling PC, for example when the Monitor module is running, the green LED will flicker (it may appear to be constantly lit at a low level).

## No Sandwich Box Found

When a Sandwich Box is connected and switched on it should be recognised by the operating system and an appropriate sound generated.

Check that the Sandwich Box is connected to a functioning USB port and has power applied.

Cycle the Sandwich Box power and re-launch the software.

The Sandwich Box should be listed in the device manager as a USB Serial Converter (Start / Settings / Control Panel / System / Hardware / Device Manager Universal Serial Bus Controllers). If it does not appear then there may be a problem with the driver (see driver installation).

Sandwich Box Mk2 cannot be controlled by Mk3 software and vice-versa. Software is free to purchasers of Sandwich Box systems and is available on Verif-i's website

## Intermittent Problems

If the Sandwich Box produces unexpected results, such as poor trace scaling or channel scrambling, the Reset module should be run to reload operating parameters to the acquisition unit.

Running the Self Test module will show whether the system is operating correctly.

If a Reset fails to clear the problem the power on the Sandwich Box should be cycled.

## Channel Allocation Different

When a record is processed the channel allocation is read from the record header. If the channel names in the new record are different from the last record that was processed then a warning will be generated as the channels selected in the Processing Parameters are based on the channel allocation from the previously processed record.

A window is opened displaying the channel names read from the currently selected file. The user can confirm that the channels are correct and change them if necessary.

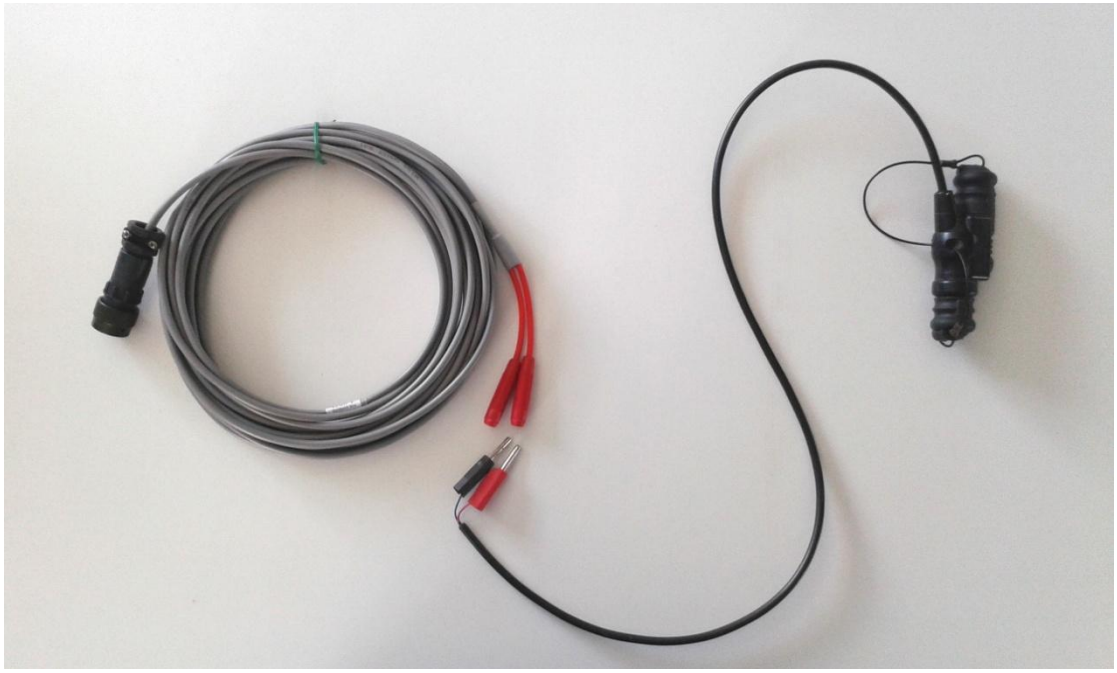
Clicking the Continue button will process the data using the displayed channel names and clicking the Cancel Changes switch closes the module without changing the parameters; in this case the data will not be processed.

# Polarity Verification

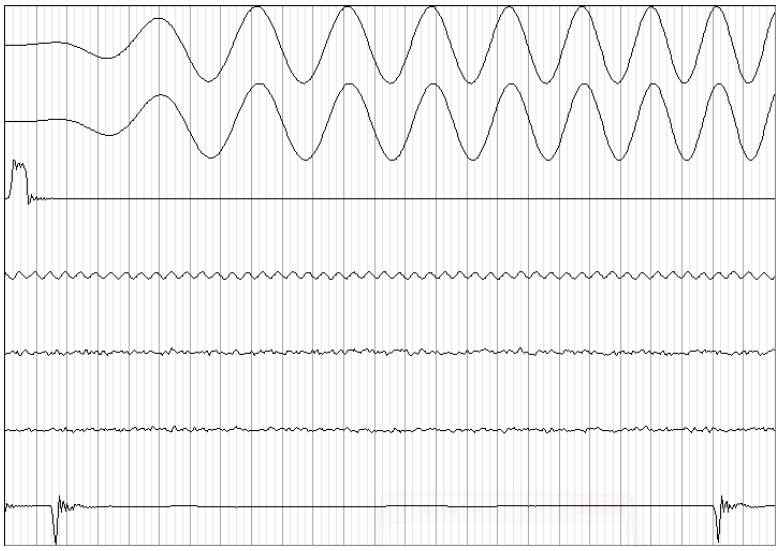
The Sandwich Box makes it very easy to conduct vibrator polarity tests as the magnetic mounted accelerometers can be easily removed to conduct tap tests.

A hardware force signal is produced in real time on pins J and K of front panel connector Output 1-4.

A connecting lead is supplied with the Sandwich Box which enables the force output signal to be connected to a recording system (cable on left in picture below). The cable is terminated in two 4 mm sockets and the user should obtain a cable to connect this to one channel of the recording instrument (cable on right in picture below).

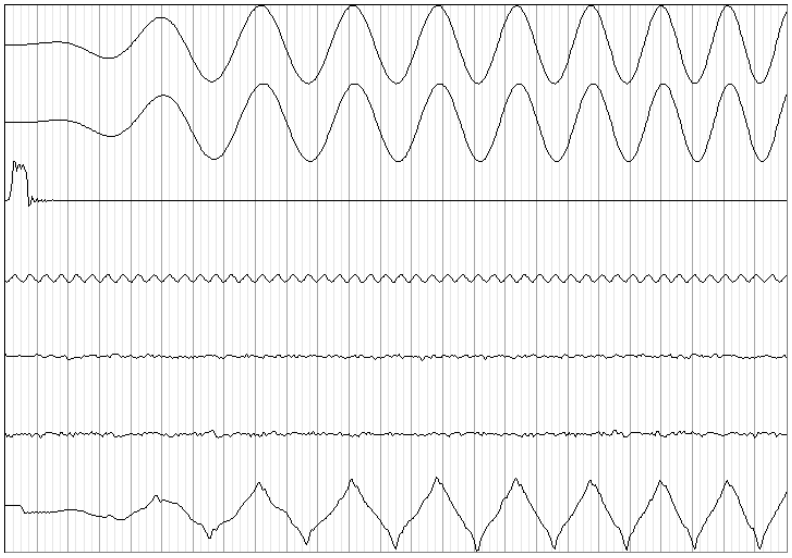


With the force signal being monitored on the recording system the user should perform tap tests on each of the two accelerometers attached to channels 1 and 2 of the Sandwich Box. For SEG polarity, tapping the bottom of the accelerometers should produce a downward break on the force channel of the recording system; if the polarity is incorrect the two 4 mm connectors should be reversed and the test repeated.



Taps break downwards for tap on bottom of accelerometer

When the polarity is correct the accelerometers should be mounted on the vibrator and a sweep recorded on the recording system. The SEG definition of polarity requires that the vibrator force signal measured by SEG polarity sensors should be in phase with the correlation reference. This can be simply checked with sight of a monitor from the recording system.



Force signal (#7) is in phase with the correlation reference (#1)

For completeness a correlated record should be produced to check that the correlation wavelet is zero phase.

**Notes:**

The real time force signal output by the Sandwich Box hardware is the weighted sum of the accelerometer signals recorded on channels 1 and 2 of the Sandwich Box only.

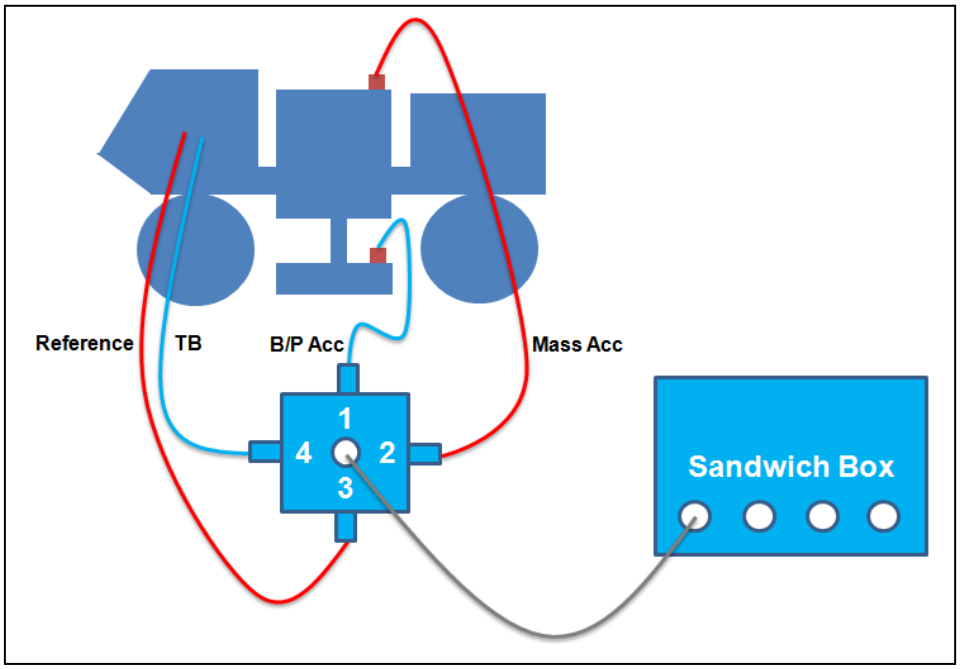
The weighting is performed in steps of 50 kg.

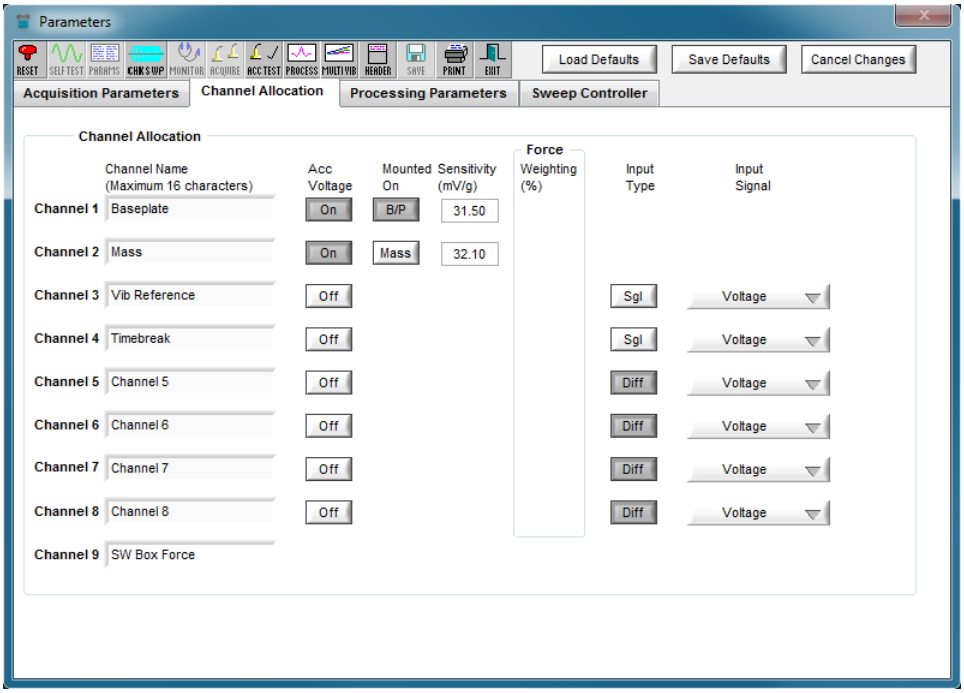
Polarity cannot be assessed by the Sandwich Box alone as there is no way to determine the polarity of the correlation reference sweep; in order to do a proper polarity test the signals must be acquired by the recording system.

# Typical Setup

The following diagrams show some of the ways the Sandwich Box can be configured. The setup is flexible and the user can connect signals in many different configurations, these are just examples.

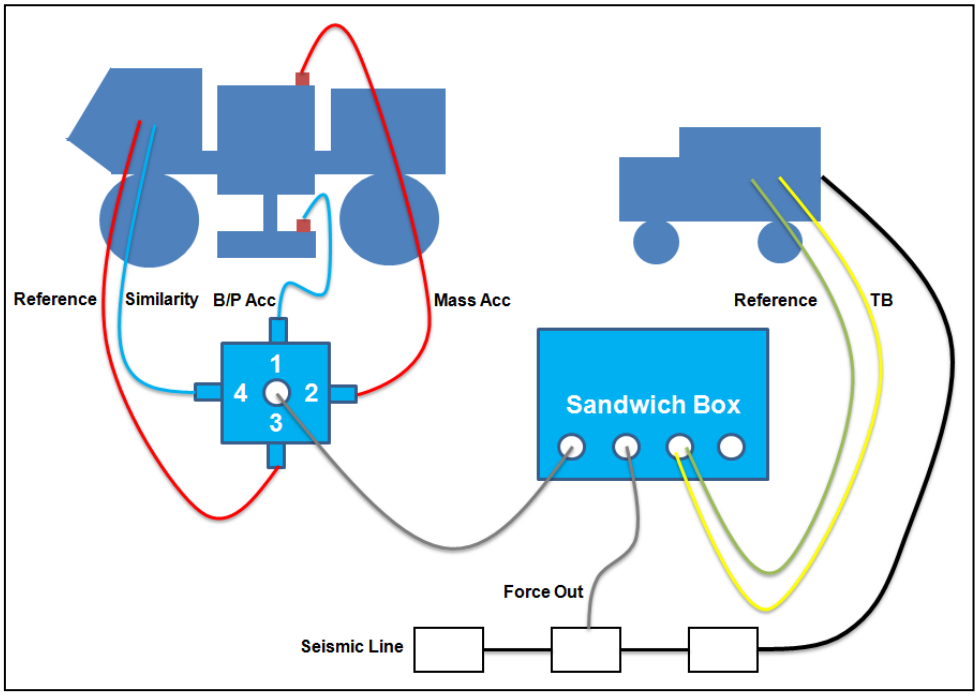
## Basic - Standalone Vibrator

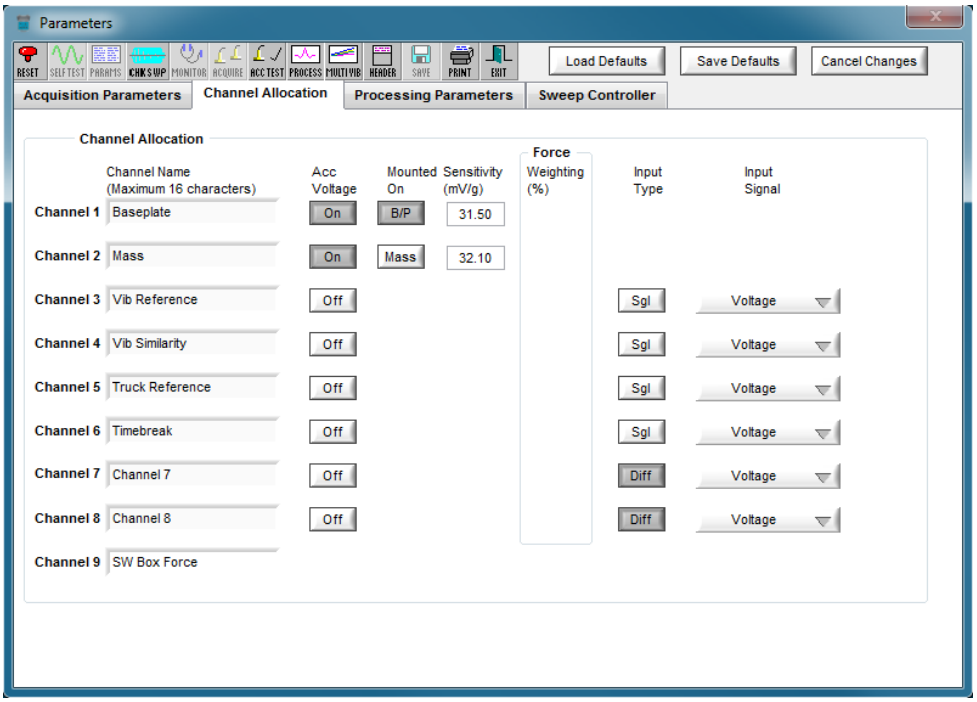



Note: This configuration has no polarity check, no start time error calculation and the digital trigger cannot be used. Accelerometer sensitivities should be taken from the supplied calibration sheets.

## Normal - With Recording Truck



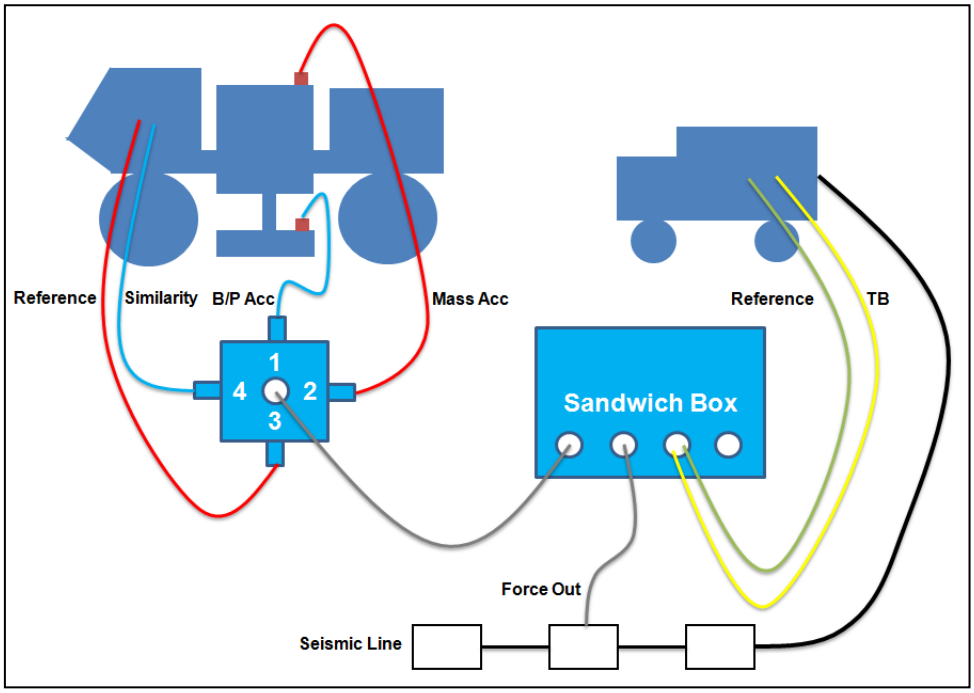



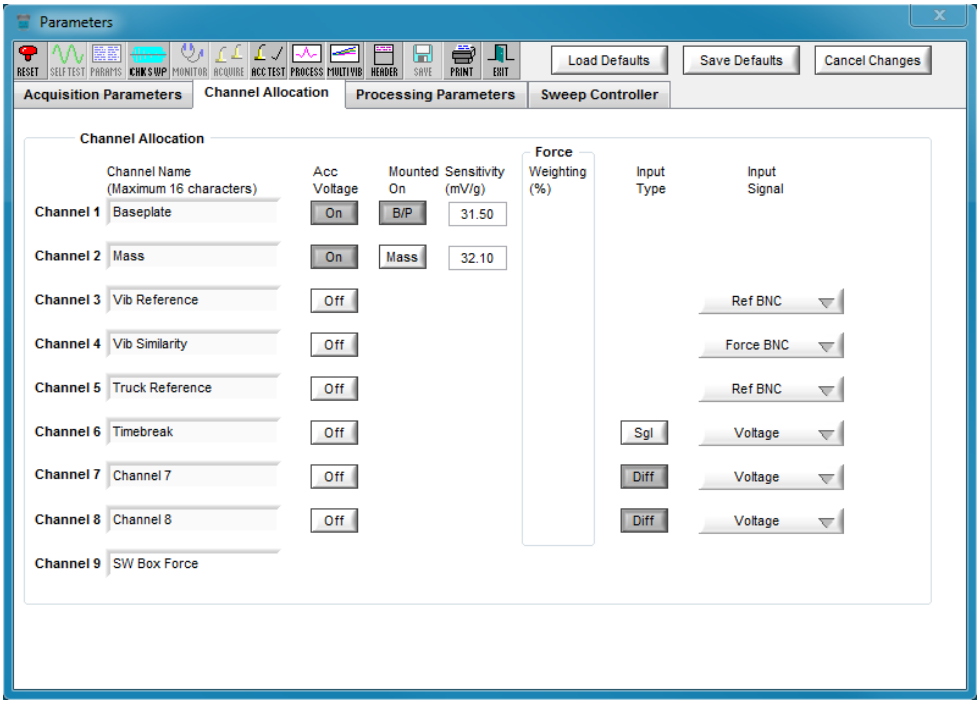

Configuration of the unused channels (7 and 8 in this case) is unimportant.

Vibrator polarity can be established by performing tap tests on the Sandwich Box accelerometers and making records on the recording system then recording a vibrator sweep using the Force Out cable to connect the signals to the seismic recording instrument.

Comparing the Truck and Vibrator reference sweeps allows the Sandwich Box software to calculate the vibrator start time error.

## Normal - With Recording Truck and Sercel Vib Electronics




This configuration is similar to the pervious example except that the input types are automatically selected depending on the connector on the vibrator electronics that is used (BNC connectors or Similarity connector).

The similarity signal from the DSD is scaled by the Sandwich Box software and can be used to display the vibrator force output in decaNewtons (or pounds) for comparison with the Sandwich Box results

# Specifications

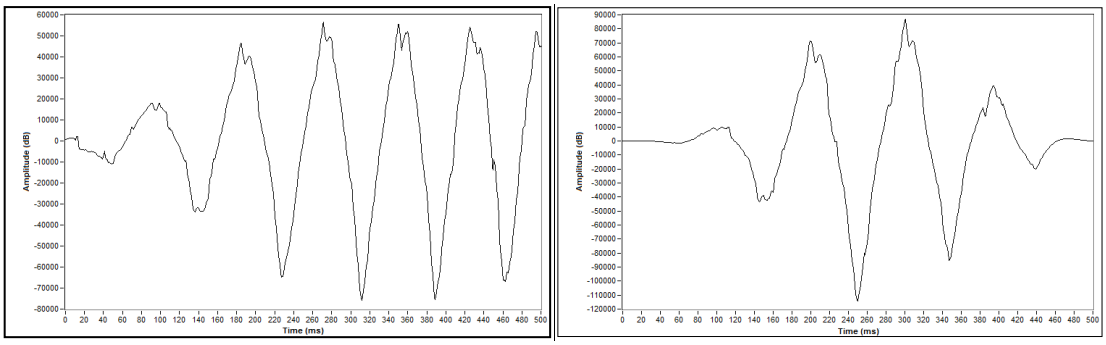
| | | |
|---|---|---|
| Supply voltage | : | 9 to 18 V DC (overvoltage protection blows the fuse at +18 V) |
| Supply current | : | 500 mA @ 12 V (reverse polarity protected) |
| Accelerometer current | : | 5 mA |
| Maximum input voltage | : | ±15 V |
| Number of channels | : | 8 |
| Sample interval | : | 4, 2, 1, ½ or ¼ ms |
| Maximum record length | : | 128 s |
| Record format | : | SEG-D (plus optionally SEG-Y or .vfi) |
| OS requirement | : | Windows Vista, 7 or 8.  32 or 64 bit |
| Processor requirement | : | Support for SSE2 instructions |
| PC interface | : | USB 2 or 3 |
| Min. monitor resolution | : | 600 x 800 |

# Distortion Calculation

Distortion in the Sandwich Box is total distortion rather than the more normal harmonic distortion. Calculating the distortion for a sweep frequency is problematic as the frequency of the signal, and hence the distortion components, is changing continuously.

The sweep is divided up into overlapping time slices and the distortion for each slice calculated and assigned to the centre of that window; the first distortion value in the sweep will be assigned half way through the first window, hence there is a gap at the start of the record where there is no distortion result.

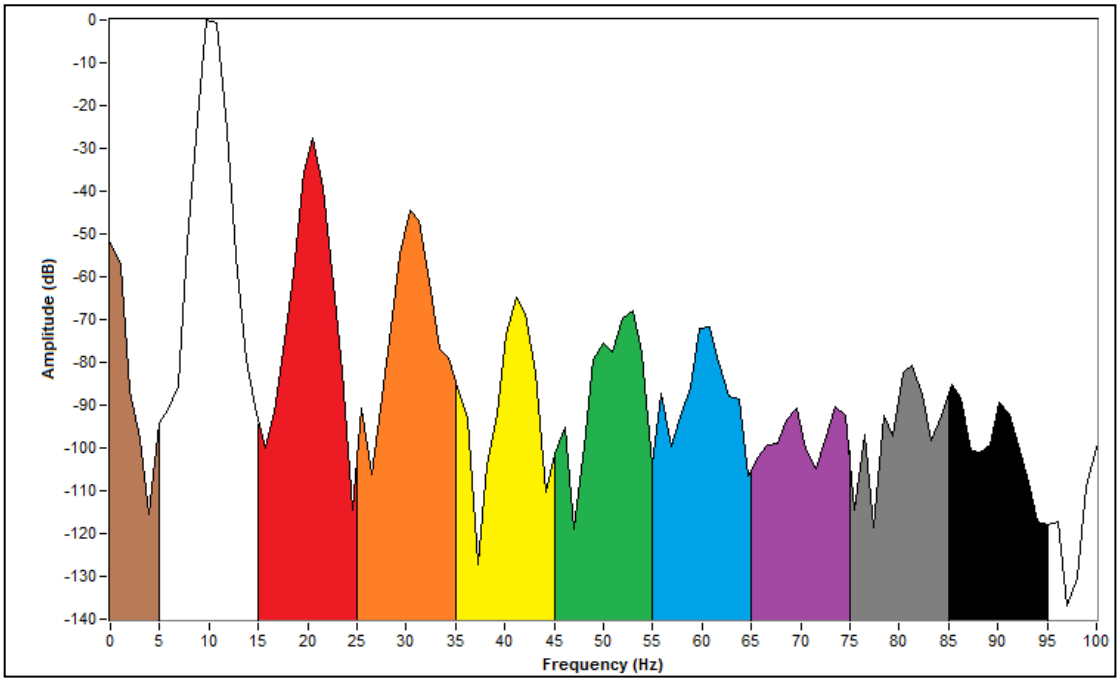
The first time slice contains the first nine cycles of the sweep and this is windowed, to prevent discontinuities as the start and end of the slice, and then converted to the frequency domain using a Fourier transform.




The peak amplitude in the frequency domain is calculated and this is taken to be the fundamental frequency, although as the frequency is changing during the time slice the energy is smeared over a range of frequencies.

All of the energy between 0.5 and 1.5 times the fundamental frequency is summed and assigned to the fundamental frequency (the white portion of the plot below). The energy from 1.5 to 2.5 times the fundamental is assigned to second harmonic distortion (red), and so on up to the ninth harmonic. Energy more than 9.5 times the fundamental frequency is ignored. The energy from zero to 0.5 times the fundamental frequency (brown) is assigned to sub-harmonic distortion.

The time slice above is approximately 500 ms wide so the first distortion result will be plotted 250 ms after the start of the sweep. Another result of the short slice length is that the FFT only yields one result per Hz.




Total distortion is calculated from the formula:

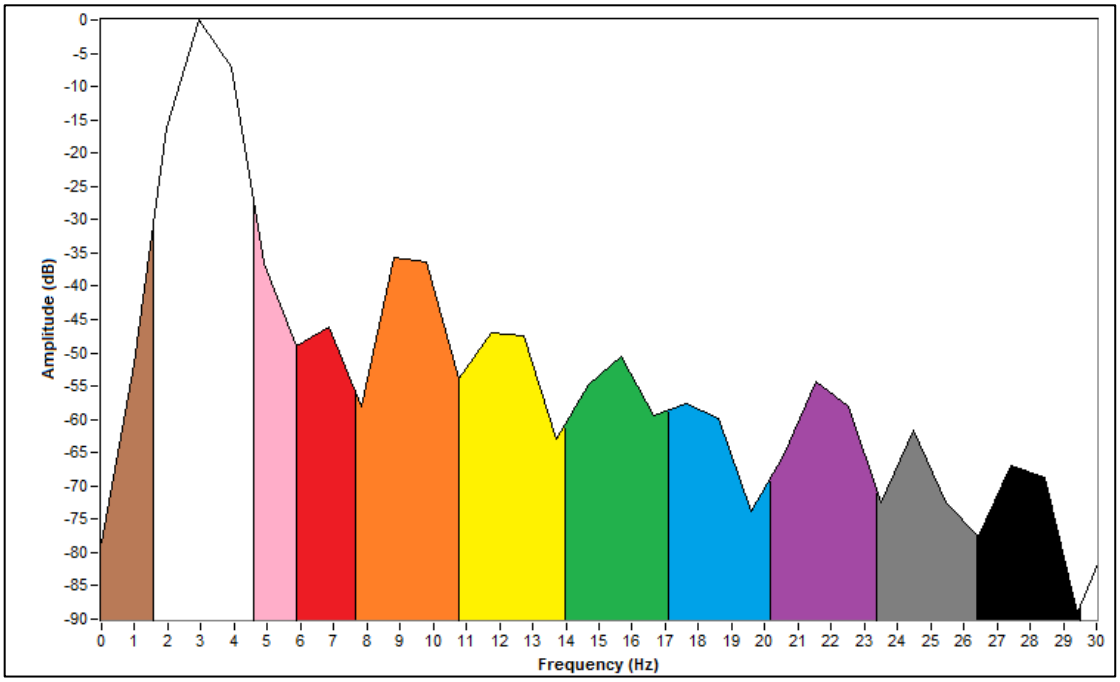
$$Distortion\ (\%) = \frac{100}{A}\sqrt{\sum_{n=2}^{9} an^2}$$

Where *A* is the amplitude of the fundamental and *an* is the amplitude of the $n^{th}$ harmonic.

## Low Frequency Distortion Algorithm

For lower sweep frequencies the harmonics are closer together as the spacing between each harmonic is equal to the fundamental frequency. At very low sweep frequencies energy from the fundamental frequency may spread into the range of frequencies assigned to the second harmonic.

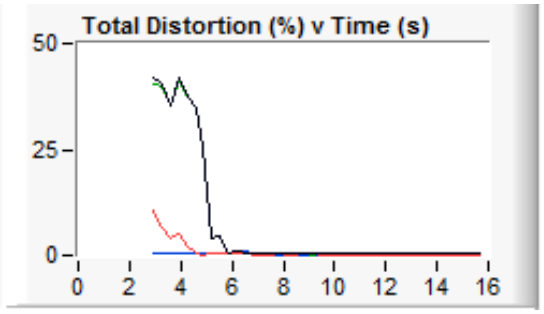
The plot below is taken from a time slice where the fundamental frequency is approximately 3 Hz. The second harmonic is measured from the energy between 4.5 Hz and 7.5 Hz - this is represented by the pink and red areas in the plot above.

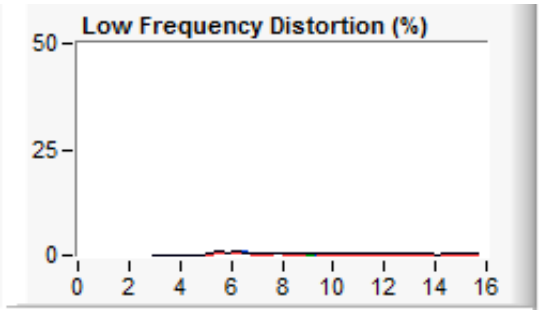



It can clearly be seen that the pink area of the plot contains energy from the fundamental that has leaked into the area assigned to the second harmonic. Performing a distortion analysis of this data would give an apparently high level of second harmonic distortion as it contains energy from the fundamental frequency.

In order to mitigate this problem the Sandwich Box processing module contains a Low Frequency Distortion option. Enabling this option prevents the pink area of the plot being included in the second harmonic measurement and thus gives a better approximation of the actual vibrator distortion.

The best way to determine whether the Low Frequency Distortion option should be enabled is to process the vibrator reference sweep. This should have little or no distortion, so if the analysis indicates that there is significant amount of distortion the Low Frequency Distortion option should be enabled and the reference sweep reprocessed. An example of this is shown below:




Note that all distortion plots are renamed to show that the Low Frequency Distortion algorithm is in use.

# Front Panel Connectors

### Input 1-4

Input Connector 12-10S

| Pin | Signal |
|---|---|
| A | Channel 1 High |
| B | Channel 1 Low |
| C | Channel 2 High |
| D | Channel 2 Low |
| E | Channel 3 High |
| F | Channel 3 Low |
| G | Channel 4 High |
| H | Channel 4 Low |
| J | Timebreak High |
| K | Timebreak Low |

### Input 5-8

Input Connector 12-10S

| Pin | Signal |
|---|---|
| A | Channel 5 High |
| B | Channel 5 Low |
| C | Channel 6 High |
| D | Channel 6 Low |
| E | Channel 7 High |
| F | Channel 7 Low |
| G | Channel 8 High |
| H | Channel 8 Low |
| J | Timebreak High |
| K | Timebreak Low |

**Output 1-4**

Output Connector 12-10P

| Pin | Signal |
|---|---|
| A | Channel 1 High |
| B | Channel 1 Low |
| C | Channel 2 High |
| D | Channel 2 Low |
| E | Channel 3 High |
| F | Channel 3 Low |
| G | Channel 4 High |
| H | Channel 4 Low |
| J | Force Signal High |
| K | Force Signal Low |

**Output 5-8**

Output Connector 12-10P

| Pin | Signal |
|---|---|
| A | Channel 5 High |
| B | Channel 5 Low |
| C | Channel 6 High |
| D | Channel 6 Low |
| E | Channel 7 High |
| F | Channel 7 Low |
| G | Channel 8 High |
| H | Channel 8 Low |
| J | |
| K | |

**Battery**

Input Connector 8-33S

| Pin | Signal |
|---|---|
| A | +12 V |
| B | 0 V |
| C | |